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GYMNASTIC EXERCISES OF ITALIAN CUIRASSIERS.

WE herewith publish reproductions of a series of photographs which are remarkable specimens of snap-shots, showing surprising jumps and apparently impossible positions. These views are also worthy of notice as illustrating the very creditable achievements of a corps d'elite of the Italian army. The cuirassiers are all men of imposing stature and uncommon handsomeness, and their martial appearance is further enhanced by their dazzling uniform; they are universally admired at home and abroad. Our pictures show cuirassiers jumping hurdles, four men at a time, or singly; the exercises on horseback are such as required for a body of men forming part of the guards, the personal defenders of the royal family, and must be ready to protect it by brave acts in any emergency. The result of such exercises, with this picked body of men, is excellent; some of the exercises are the same as those practised at the riding-school of Tor di Quinto, of which we published photographs some time ago, showing how Italian cavalry officers may, on their patiently trained horses, descend safely on steep declivities. The cuirassiers, too, perform equestrian tours de force. These have been particularly remarked outside of Italy, setting at rest the old idle story that Italian officers could not ride on horseback. For our engravings we are endebted to L'Illustrazione Italiana.

ITALIAN CUIRASSIERS JUMPING HURDLES.

CAPT. D'ALESSANDRO JUMPING.

CUIRASSIERS RIDING DOWN HILL.

GYMNASTIC EXERCISES OF ITALIAN CUIRASSIERS.

Mr. O. Reynolds states that the causes of the slipperiness of ice is that the lowering of the melting point by pressure forms a very thin liquid film.

EVOLUTION OF TECHNICAL EDUCATION IN ECONOMICS, POLITICS, AND STATECRAFT,

AND THE WORK OF THE FRANKLIN INSTITUTE DURING SEVENTY-FIVE YEARS.*

By ROBERT H. THURSTON, Corresponding Member of the Institute and Director of Sibley College, Cornell University.

THE ideal education of the old Greek who would teach the youth of his country "to speak the truth and to ride a horse," although by no means as comprehensive as the "complete and perfect education" of John Milton, is, at least, typical of the best thought of the educator of our own time, and especially is it representative in a way of the ideals of the advocate of the evolution of the technical education of people with a view to the preparation of the great body of "plain people" for "the sequel of their lives." The seeking of truths, of facts and data, and of methods of utilization of such truths in the interest of the people, in the promotion of their moral, social, and intellectual advancement, of that material progress which underlies all, constitutes real education.

This constitutes a problem for the economist, for the wise political leader and for the statesman of every grade. For the ancient aristocrat and gentleman, honesty and ability to bear oneself as became a gentleman, in all out-of-door exercise, as well as in social intercourse with other gentlefolk, were recognized as the fundamental elements of a proper training. Little more was then needed and little more was prescribed. As time went on, not simply the speaking of truth but the learning of truths, not simply the riding of a horse but all manly exercises and warlike accomplishments, were demanded as essential elements of the curriculum of the gentleman. Later as the arts of war became less exercised and as those of peace became more and more vitally important with all classes, the clergy of Europe came to dictate the form and extent of the education of the gentlemen and of the well-to-do classes of the time. Even gymnastic exercises fell into the background with the drifting out of sight of the arts of war as a part of the regular education, and the modern, monastic, gymnastic methods of education took shape and controlled all schools. Still later, after political power had fallen out of the hands of monarchs and nobles into the hands of the people and it had come to be seen that the contemporary education was suited only to the wealthy and aristocratic classes, a new education came into existence and Bacon and Descartes, Milton, and the Marquis of Worcester and Vaucanson sought the development of this field by the introduction of systems of training of the people in such manner as would give them not only a knowledge of language and of literature, of history and of philosophy, but an acquaintance with the sciences, pure and applied, and with the scientific bases, and even the actual processes, of these arts the practise of which must, with the great masses, occupy their entire adult and active existence.

In early historic and prehistoric times, government, so far as developed, was simply a system of forcible control of the masses of the people with a view to the advantage of the ruler and for the purpose of securing

* Delivered at the Anniversary Meeting of the Franklin Institute, National Export Exposition, Philadelphia, October 7, 1899.

for him means of offense and defense in his constant warfare with his neighbors. As time passed and regal power was taken from the hands of the monarch and fell into those of the aristocratic classes, the art of war was cherished largely for the same reasons as those controlling the emperors and the kings of earlier days; although the arts of peace assumed larger importance as wealth and luxury, and the always resultant effeminacy of the wealthy classes brought into being a demand for greater intricacy of life and increasing diversification of industries, while the training of skilled workmen has constantly assumed greater and greater importance to the state. The science of economics, the true science of politics and the real and highest duty of statecraft thus gradually came to be, by a few great minds, clearly recognized.

Comenius and Froebel, Milton and Worcester, Descartes and Vaucanson, all saw clearly the real meaning of the Greek ideal, for later times, and all did what they could to introduce a broader and a better curriculum and to adapt the scheme of general education more perfectly to the needs of the people. To-day every thoughtful and well read and experienced educator sees that a true rendering of the Greek ideal into contemporary form would dictate the education of the people for the life and work of the people, the universal adoption of manual training in public schools, the evolution of a technical side to education, which, coupled with the older, gymnastic forms, should give to every ambitious youth opportunity to learn the scientific, the logical and formal basis of the art into which he feels himself impelled by natural predilection, and that it should include in its range, not only all the literatures and their languages, all the sciences and their applications, and all the arts of simple accomplishment, but, even more completely and thoroughly the arts and vocations of common life, to the extent to which they lend themselves to scientific and logical methods of instruction. Only thus can a truly wise system of education of the people for the life and work of the people be founded.

To-day the arts of war engage the attention of comparatively few; the arts of peace occupy practically the whole mass of the people. The chief duty of the statesman, as well as of the economist, as well as of the wise leader in politics, is no longer primarily, almost solely, the study of war and of strategy, of diplomacy and of the raising of armies; it is now rather primarily and principally the promotion of the business interests of his country, the advancement of the arts of peace, the maintenance of those industries providing the essentials of modern civilizations, the diversification of industries for the purpose of giving larger opportunities and greater industrial and political independence to his own people, and the provision of that education, necessarily largely technical, which best meets the needs of the people as individuals and as a nation.

To-day the acuteness of the political leader and the wisdom of the statesman may be very accurately gaged by the attention which he gives to the education of the people and especially to a systematic development of that technical education which has so long, but so slowly, been in process of evolution as a complement of the gymnastic, purely literary curriculum of older times. The moral and intellectual magnitude of the educator may be measured by the extent to which he has come to appreciate and to promote these evolutionary movements. The states of Germany, of France, the educators of our own country, particularly, illustrate this fact. Glancing over the compilation of testimony favorable to the inauguration in the earliest days of our republic of a national university, as representative of a national and public scheme of education of the people, as printed by the national committee, one sees at a glance that the names are those of the greatest statesmen of their time; the grander his statecraft, the nobler his plans for educational development, the larger the measure of the man in all ways. This has been true from the days of Xenophon and Herodotus to those of Washington and of Jefferson, and of the founders of German technical education, of the "Land Grant Colleges," and of that Cornellian system which would unite in one great institution systems of education of all men in all studies; such as would prepare, equally well and with absolutely equal honor, the scholar for the rostrum, for the pulpit, and for the professor's chair, the lawyer for his courts, the physician for his hospital and for ministration at the sick bed, the engineer for construction of railroads, canals, bridges, and steamboats and steam engines, the farmer for all forms of agriculture, and the artisan for the workshop, factory, and mill. Of these classes a thousand require scientific instruction where one depends upon literature for his support; hundreds demand a knowledge of the scientific basis of the arts where one needs tuition in language; scores seek professions having a scientific foundation where one can utilize in later life and for his own personal advantage where the "liberal" education of the so-called "learned professions" finds one worthy application.

Biblical history tells us that in the eighth generation of the race of Adam, Tubal Cain was "the forger of every cutting instrument of brass and of iron."* The metal-working trades were thus established, necessarily, at the very beginning of civilization, and apprenticeship, which is technical education, must have become an established system before a vocation could become a trade, before the art of the individual could become the art of a guild. Life in cities could not take form until the trades of the manufacturing industries were fully organized, and the age of the cities of antiquity, of ancient India, of Assyria, of Babylonia, of Asia Minor, of Egypt, Greece, and Italy, measures approximately the space of time separating us from the beginnings of manual training and of trade instruction which are, in turn, the foundations of modern technical and professional training. When the great deluge washed away the product of the antediluvian industries, the erection of the Tower of Babel was the construction also of a memorial to the brickmakers of the reviving world. Every modern fundamental profession, trade and vocation probably has a history approximating in its length that of the race itself. Technical education is prehistoric in source, and its history has simply been that of an originally simple and non-scientific, an empirical system developing by an evolution under conditions, sometimes favorable, sometimes restrictive, in such manner as to make its progress extremely variable in rate and method from its earliest to its latest phases.

George Ebers, the famous Egyptologist and hardly less distinguished and certainly more widely known historical novelist,* finds records amid the tombs and pyramids of the valley of the Nile indicating the existence of a great school and college system supported by the Pharaohs, fifteen hundred years and more, earlier than the Christian era. For the time, indeed, it was more nearly a true university system than has been seen in Europe since that era, and hardly less universal in its breadth than that inaugurated by Ezra Cornell in the United States of North America in our own generation. Organized in the "House of Seti," in Upper Thebes, it excelled the still older foundations at Heliopolis and at Memphis in its universality and especially in its extension of its curricula into the fields of technical learning. In its preparatory school, even, were departments of theological, mathematical, legal, astronomical, and pedagogical technology. Its great library contained many thousand rolls of papyrus. Schools of art, architecture, sculpture, painting and engineering, so far as developed at the time, insured the cultivation of the æsthetic with the useful and their union in construction. In magnitude, only Thotmes' great temple exceeded this vast pile. More than this, it was a system of free schools and colleges to which every citizen had a right to send his sons. Dormitories for the young men of the wealthier and noble classes were adjacent and famous priests guarded and guided the pupils. "Scribes," university professors, free from other labors, were given opportunity for study and research in the highest realms of science, of literature and of art, pure and applied. Its faculty numbered above eight hundred and there were three "prophets" appointed as directors of its colleges, of whom the high priest was the senior. Splendid residences were assigned the faculty and of these that of the high priest was of unequaled magnificence.

Its successor, the "House of Rameses" was similarly but even more liberally planned, 1,300 B.C. The University of Rameses was in existence a thousand years and more before the foundation of the later and possibly even greater University of Alexandria.

Technical education finds its earliest at all complete records in the accounts by the Greek historians of the work performed by the technical staff of the great University of Alexandria, during the centuries elapsing between the foundation of that first most complete of universities and its destruction by the Saracens.† When Hero taught mechanical engineering and Archimedes the art of war, when Hipparchus lectured on astronomy and measured the periods of planets and the eclipse cycles and the disciples of Aristotle gave form to a logical method, technical education took on a distinct form and became recognized as an essential department of instruction. The Alexandrian University was not only the first such great educational organization; but it was in a true sense, the first university and, for the first time—in fact, for the only time in the history of education—an institution properly so-called; since then and there, only in all the course of history, up to our own time, was the endeavor made to offer instruction in all the literatures, in all sciences and in all the arts of the time. Ptolemy, in its foundation, sought to provide what Ezra Cornell aspired to organize, "An institution in which any person might find instruction in any study." Aristotle and his disciples despised no fact and respected all forms of knowledge.

The "Museum" of Alexandria was the birthplace, as Draper has truly said, of all modern science. Other nations had earlier studied natural science; other civilizations had still earlier produced great schools and great men, curious in the observation and study of natural law and nature's marvelous operations; but it was in Alexandria and in the time of the Ptolemies that we find the earliest traces of a correct method of scientific investigation and evidences of researches to discover facts and natural laws—real scientific research, "the interrogation of nature through systematically planned and prosecuted experiment."

The first and most universal of universities—the times being considered—was founded to promote the acquisition of all knowledge, in all fields of history, philosophy, literature and natural science, to illustrate the methods of Aristotle, the first philosopher recognizing what we are, in our conceit, prone to designate the "modern" scientific method—first seeking facts, next deducing laws, then constructing a science by the codification of the natural laws thus revealed. The older Greek "philosophy" of the imagination was rejected and the true philosophy of fact and sound logic and scientific deduction was brought into practise. The speculative philosopher was retired and the experimental philosopher, the scientific investigator, took place in the van. Archimedes investigated the laws of hydraulics, Ptolemy those of optics, Hipparchus gave his contemporaries and his successors, even to our own time, valuable results of research in astronomy, using instruments of precision and making exact measurements as bases for his computations.

Euclid created geometry, and the world still finds his work perfect. Archimedes' mathematical studies gave him pre-eminence as a leader in his department and no rival appeared for many centuries, and even up to the time of Newton. In applied sciences, in his discoveries relating to specific gravity, in his inventions of the lever, the screw, the burning mirror, apparatus of war and of peace, he proved himself the first great producer of the mechanisms and machinery of the engineer and the physicist. Eratosthenes was the great geographer, whose work was the beginning of all that we to-day know, both as to fact and as to system, and he founded physical geography.

These mighty men of mind recognized the facts of rotations of the earth, the nature of heat as a form of energy, the general distribution of light and heat and the variations of climate throughout a spherical earth. So accurate were their astronomical measurements that Ptolemy was able to discover the moon's eviction, and Hipparchus the procession of the equinoxes, and measured its period. The motions of the planets were observed and discussed, and Timocharis noted the phases and movements of Venus.

Ctesibus invented fire engines and water clocks. Hero described the first steam engine, that form which is to-day coming in again, two thousand years after Hero, in the form of the steam turbine, as a rival of the complicated and costly and imposing machine which is the product of an evolution having a history, as a train of mechanism, of just one century.

Sosigenes, of Alexandria, in the time of Julius Cæsar, went to Rome to rectify the then confused calendar, and thus this first great university, the prototype of the modern university of our own States—a university without intermediate representative in all these centuries, and which we now recognize as in fact a real and great technical college, carried its wonderful work through the centuries immediately preceding and succeeding the Christian era.

The Saracen conquest of Egypt resulted in the destruction, in a large degree, of this majestic edifice of learning; but the Saracens themselves, once the conquest was complete and they were permitted to settle down to the pursuit of the arts of peace, became inspired with the genius of investigation; the conquerors took up the work of the conquered and we now credit the Arabian philosophers and men of learning with preserving and advancing human knowledge in hardly less degree than did, in the earlier centuries, the Greek Ptolemies and their allies.

The energy of a race is like that of a river, small or great, quiet or torrential, flowing from earlier to later times, compelled by natural forces constantly to follow a general direction determined by the topography of surrounding conditions, to be sure, but always forced to move on until its stock of energy is exhausted. If war demands the expenditure of this energy, it becomes destructive as a mountain torrent in time of freshet or cloudburst; if peace supervenes, still this energy must find application, and in Egypt, after the close of the Alexandrian campaign, it fructified that intellectual domain as the Nile fertilized the valley which it traversed. Similarly, after the Greek and Roman civilization had been overwhelmed by the Goths and Vandals from the north and by the Saracens in the valley of the Nile, the Arabians diverted their energies into new and useful channels and the flow of the stream of Saracen energies became subdued to the fructification of the whole of Northern Africa and of Spain and the development of pure and applied sciences among the Ptolemaic people was paralleled by that later observed among their conquerors. Destructive energy was replaced by constructive operations in all departments of human activity. Bagdad became a great metropolis in which, far more than in the New York of to-day, learning and scholarship and Aristotelian research were encouraged and honored. Haroun-al-Raschid instituted a school in every mosque in the whole Saracen empire, and his successor, Al-Mamum, A.D. 813-832, like the first Ptolemy, built up a great center of learning at Bagdad, collecting great libraries, calling to his court and to his colleges the great men of the age, from all countries; his was the Augustan age of the Saracen empire.*

The Saracens boasted that they had produced more poets than all other nations combined; that they developed further than ever had been done before the scientific method now universal; that they substituted a study of nature, of phenomena and fact for speculation; that they promoted mathematics and the exact sciences in a hitherto unexampled manner; that, in their time, alchemists founded the science and the art of chemistry; that their learned men produced works on mechanics, solid and fluid, optics and astronomy, geometry and trigonometry, invented algebra and adopted the Indian numeration and figures. They invented all sorts of distilling, filtering, heating and fusing apparatus, instruments of precision for the astronomer, the chemist's balance and the simpler mechanical combinations. They even constructed tables of astronomical quantities, of specific gravities and other scientific reference compilations. The library at Cairo grew to enormous dimensions and is said to have included not less than 6,500 works on astronomy alone. This was a circulating library as well as of reference. The Spanish library of the khalifs is said to have numbered 600,000 volumes; its catalogue filling forty-four volumes. It is said that a physician was compelled to refuse the invitation of a sultan, to Bokhara, because the transportation of his library would have required 400 camels. Another physician, Honian, at Bagdad, maintained a regular business of translations from other languages and issued versions of Plato, of Aristotle and of other ancient learned authors. All then known fields of knowledge and of research were cultivated, an immense literature was developed and all this without let or hindrance, without the slightest censorship, on the part of the monarch. All sorts of books of reference were produced, including an "Encyclopedic Dictionary of the Sciences" by Mohammed Abu Abdallah, and colleges dotted the whole extent of the empire. Colleges were then, as now, founded by wealthy men and provided with a permanent income by endowment.† One such college, at Bagdad, with an income of 15,000 dinars, taught 6,000 students of every class, rich and poor, noble and plebeian alike, and free scholarships were provided for the needy and ample salaries for the faculty. Of these learned teachers and investigators Al-Mamum asserted: "They are the elect of God, his best and most useful servants, whose lives are devoted to the improvement of their rational faculties: the teachers of wisdom who are the true luminaries and legislators of this world, which, without their aid, would again sink into ignorance and barbarism."

Professional schools were organized; that at Cairo setting the example of stringent entrance requirements for all who would study medicine, long before the foundation of the European school at Salerno in Italy. In all directions, in the philosophies, in the sciences, in the arts, in all industries, this fund of stored energy of the Saracen race found useful expenditure. The resulting civilization was far more lofty and admirable than was that of Europe during those and for many succeeding centuries. In fact, it was only in the fifteenth century that sufficient liberty was enjoyed by European men of science to permit them to enter freely upon that now familiar field of intellectual occupation, and it was only at the beginning

* Gen. iv, 22.

* Professor of Egyptology at the University of Leipsic.

† Intellectual Development of Europe. By John W. Draper. New York, D. Appleton & Company, 18.

* Draper.

† Gibbon.

of the seventeenth century, in Europe, that any really notable progress began. Since then the acceleration of the movement has been like that of a falling stone.

Technical learning and the technical and professional schools of the Saracens came into Europe mainly by way of Spain, and the Moslem conquerors of that country made famous their centuries of rule by promoting the arts and sciences in all practical ways. By the tenth century that country had become a center of learning from which streamed, throughout the continent, the rays of scientific research and the accumulated learning of all the then existing departments of science. The practical outcome was seen in well-built, paved, and lighted cities, in heating, ventilating, and elaborate furnishing, on a scale and in a manner that even our own time may admire and in some respects imitate. Especially admirable were their systems of social life, with freedom from the elsewhere universal dissipation of the time, with "feasts of reason and flow of soul" in place of banquets of savage character and flow of bowl. Learned men of all countries were ever welcome guests, and Andalusia became the resort of scholars and philosophers, and of men noted for their progress in scientific research, from all countries and all nations and of every race. All were equally welcome and all alike honored. When, in the fifteenth century, the Moors were driven out of the peninsula, the Castilians found a great civilization well established and the foundations of true learning well laid. The efforts of the anti-scientific parties of the time were never again able to entirely quench this great light; it has grown steadily and pervaded not only all of Europe but all the known world through its stimulation of research, its promotion of inventions, and its application of all sciences and all arts in their thus improved state to the development of the best interests of the common people. In this vivification the germs of our modern civilization, the Jews were particularly active and effective, and this was one of the most powerful influences leading to their later banishment. Their expulsion from Spain led to the distribution of the new civilization throughout the whole continental Europe, wherever a Jew was admitted.

The Greeks thus carried the torch of scientific learning from their earliest days, antecedent to Aristotle and Alexander by probably centuries, up to the Saracen conquest; the Arabian civilization carried it on into the fifteenth century, effectively cultivating a true philosophy of nature for at least eight hundred years; then came our own modern civilization as developed and evolved in France, Italy, Germany, Belgium, Spain and Great Britain. Its main progress has been observed during the last two or three centuries and its culmination, if culmination there be, has been observed during these last seventy-five years, since the establishment of existing systems of power-production, of transportation and of manufactures—and the inauguration of our recently developed systems of public schooling and higher scientific and technical education.

The study and investigation of mechanical science practically began in Europe with the work of that wonderfully versatile engineer, Leonardo da Vinci; whose biographies, written by men utterly ignorant of his greatest achievements, are devoted to accounts of his painting and sculpture, his verses and his travels and battles and sieges. Leonardo was the instigator of the sixteenth century renaissance of science and the technical arts and professions.* He was familiar with the Saracen literature and with their scientific work; their books and their learned men having come, by his time, into Italy and the south of France. He adopted research as the only guide in scientific matters, revived the Aristotelian and the Averroesian philosophical systems and applied these true methods to his work in applied mechanics, physics and all the natural sciences with which he, more than any other man of his day, probably, was familiar. His technical applications of the sciences were numerous and valuable and his familiarity with the literature and the science and with the learned men of his time gave currency to his productions that could not otherwise have been attained. He thus firmly founded the existing systems of thought and work in scientific and technical matters. All modern science and all contemporary workers in scientific and technical fields, whether of the schools or of the professions or in research, owe more to Leonardo than the average student can realize.

Finally came Newton and the great mathematicians, Lavoisier and the famous chemists, Boyle and the succeeding physicists, Watt and all the wonderful inventions of our century. By the end of the first quarter of this century, the advancement due to all these developments was well underway and that world with which we are concerned took form.

(To be continued.)

LEATHER INDUSTRY IN GERMANY.

ACCORDING to the Consul-General Sir Charles Oppenheimer, a result of the study by German experts of American progress is the establishment of a German leather industry. Germans claim to have themselves invented the manufacture of leather with the use of chrome salts, and Dr. Heinzerling, of Frankfort-on-the-Main, is named as the inventor of this process, which, in the year 1884, was finished by Schulz in America for technical use. This leather appeared first in the latter eighties on the American market. It is said especially to possess greater resisting power against dampness than ordinary chevreau leather. Six to seven years ago German factories commenced to manufacture chevreau from chrome. A firm bought several patents, and sent experts to America to study the process on the spot. This factory is furnished with new American tannery machinery, which is capable of turning out daily 500 dozen goat skins, and they contemplate raising the output to 1,000 dozen per day. The factory has succeeded in working off hides from various sources, with like success. Another German firm is said to have been successful in manufacturing calf, cow, and strap leather with chrome salts, according to a new process invented by Dr. Heinzerling. This success has caused great rejoicing in Germany, and German papers conclude from this that the technical and commercial methods of the Americans ought to be studied by proper skilled experts in order to be able to beat the work of the Americans. As to the branches of trade which, in this connection, are next to be taken in hand, are mentioned the shoe, bicycle, and iron industries.—Journal of the Society of Arts.

*See particularly "Il codice Atlantico di Leonardo da Vinci;" Milano: 1808.

LAMPBLACK FROM COAL GAS AND ACETYLENE.*

By GEORGES F. JAUBERT.

BEFORE going into the manufacture of lampblack, known under the name of acetylene black, I will say some words upon the industrial preparation of blacks in general.

Soot or smoke black is a substance of some importance. Germany imports each year over 1,000,000 kilogrammes (984 long tons), which, at an average of 1 franc per kilogramme (9 cents per pound), makes 1,000,000 francs. In 1894 statistics place it at 678,000 marks ($169,500), and this has increased since then. Thus, in the Black Forest, where an inferior quality of lampblack is made, five works are in full activity, having a weekly output of 3,000 to 4,500 kilogrammes (6,600 to 9,900 pounds).

According to their fineness, blacks are adapted to various uses; for example, the manufacture of printer's ink, waxes, black varnish, fine colors, Chinese ink, oil colors, etc. They are distinguished also as to purity, fineness, their shade of color, the method of making, making numerous kinds of black of which the price varies considerably. Up to the present time smoke-black has been produced by the incomplete combustion of carbon, in which it separates from the flame in a pure and finely divided condition. According to its origin we have the classes smoke-black, tar-black, and lampblack, the latter being obtained principally through the combustion of coal gas, etc.

For the manufacture of smoke-black and of tar-black, long masonry chimneys are used, connected to chambers, upon the walls of which the soot is deposited and removed by iron scrapers.

Formerly, in the Black Forest, they used as supply material resins from fir trees, while to-day they use but the residue resulting from the distillation of this resin, as well as coal-tar and heavy oils of tar; 100 parts of tar give 25 parts of black, while the residue of resins give but 20 per cent. A good cooling is essential to the manufacture of black in order to avoid its ignition upon contact with air.

All these processes give a black of but inferior quality because it is always mixed with tarry matter. Such a black will not mix with water by reason of the oily matter, and gives, when mixed with white, a brownish gray inclining to red, which excludes its use from good impression work.

Lampblack is a very valuable product and is generally obtained by allowing luminous flames of oil or coal gas to play upon cooled surfaces. These flames are produced either by ordinary oil lamps or by the combustion in ordinary burners, preferably an Argand, of coal gas made in special works. Experience has shown that the admission of a large quantity of air to this combustion increases the quality of the black, although the yield is smaller by reason of a more complete combustion. This lampblack is produced of exceptional purity. Dilute sulphuric acid, alcohol or an alcoholic solution of potash removed nothing; benzine extracted minute traces of a solid yellow substance. A combustion analysis of this black gave the following results:

Constituent.	I.	II.	III.
Carbon	99·446	97·390	99·095
Hydrogen	1·051	1·061	0·905
Ash	0·970	...	....
Oxygen	1·533	1·549	....

Sample I contained ash, II was free from it, and III was treated with benzine.

In the process of smoking, good cooling of the receiving surface constitutes always an essential condition. In practice various systems of apparatus are used. The Dreyer apparatus consists of an iron drum with polished thin walls mounted so that it can be revolved while it is kept cool by water circulating through its interior through its trunnions. A sheet iron jacket surrounds the cylinder with a space between of some centimeters, and the row of burners is placed under the cylinder. The soot is deposited upon the smooth cylinder while it revolves slowly, and is constantly being scraped off by means of a brush.

In the Thalwitzer apparatus, which in certain cases is to be preferred to the Dreyer, the soot is deposited upon a horizontal rotating metallic disk provided with a wide projecting edge and cooled also by a current of water. The flames burn below, and the black is removed continuously by a metallic scraper and falls into a hopper receptacle.

While in all these processes the black is obtained through partial combustion of carbon, the effort has been made for a long time to avoid this loss of supply carbon and to obtain carbon directly by the doubling of carbides of hydrogen by means of pyrogenic process or by electrolysis.

MacTighe proposed a method of this kind. He passed hydrocarbon vapors through excessively hot retorts and obtained by their complete decomposition carbon in the form of lampblack. The process of Schneller and Wisse may also be cited as being interesting, as it uses electric currents having a voltage of from 10,000 to 40,000 for the same purpose. The two electrodes are introduced into the hydrocarbons to be treated, the current interrupted, and the carbon separates out, immediately extinguishing the arc and serving as a conductor. Similar endeavors have been made in many instances, but they do not seem to have found an industrial application up to the present time.

By reason of the range in value and price of black it is easily understood why investigations should be made to discover methods for the purification and improvement of the black obtained. It was proposed to fill vessels with black, hermetically sealing them and then subjecting them to a red heat. However, with this scheme the elimination of tarry matter, the end to be attained, required at least five repetitions of the operation and sometimes oftener, and could be used only with very superior grades. The same may be said of boiling with soda lye with subsequent washing and desiccation. In general the black obtained from combustion is not subjected to subsequent treatment, but is simply graded according to fineness and purity.

Not long ago, among gaseous hydrocarbons for the manufacture of black, those only were used which had a double combination, such as benzine, for example, knowing that those with a simple combination, such as methane, did not separate out carbon upon heating and that triple hydrocarbons could not be obtained economically.

The discovery of carbide of calcium and the means of obtaining acetylene easily and cheaply in large quantities has permitted the application of the property it possesses of producing black. It is known that the black obtained with acetylene is a beautiful shade of exceptional fineness, very much so for certain uses. Acetylene black mixes readily with water, oil, a solution of gelatine and varnishes in general. Colors made with acetylene black are distinguished by shining brilliance and intense blackness, even in thin coats. An analysis of a sample showed, besides the entire absence of bodies soluble in benzine, alcohol and an alcoholic solution of potash, a content in carbon of about 99·2 per cent.

Referring to the theoretical yield of 92·3 per cent. of carbon, if it were obtained in practise, it would be four times greater than that of the best coal gas, and would make the manufacture of acetylene-black more profitable because of the quality of the product and by reason of the process being theoretically simple.

In detail, the experiments made to find an appropriate process to operate on a large scale have been confined to methods long employed in the production of smoke-black or lampblack. The Thalwitzer and Dreyer system was first experimented with. Although acetylene-black deposited upon the cold cylinder, just as the black from other hydrocarbons, obstacles were met with which prevented the application of the process. By reason of its lightness, dryness, and flocculent nature the black scattered about the place instead of falling into the receptacle when scraped off, and was a problem difficult of solution. The ordinary round steatite burners, which answered well for coal gas, were in a short time completely obstructed by carbon deposits and cracked after becoming red hot. The slit burners were obstructed in a short time. The burners ordinarily used with acetylene did not pass enough gas. Experiments were made with the Bunsen burner, but their uselessness was soon discovered because the high temperature produced during a slow rotation permits excessive heating and ignition of the deposited soot. On the contrary, with a more rapid rate of rotation, particles of black detached themselves and floated about under the influence of the air current and centrifugal force. These difficulties led to the adoption of the flaming process for acetylene with certain modifications.

In the chamber system the obstruction of the burners and the great heat of the acetylene flame produce certain inconveniences. Moreover, the quality of the product is not so good as with the first process because the flames burn laterally and obliquely, from which results overheating of the flues and partial decomposition of the gas before burning.

For acetylene, the processes which present the most importance are those, such as that of Tighe, Schueller, and Wisse, dependent upon the decomposition of gas out of contact with oxygen. We know since 1862, through the admirable work of Berthelot, that acetylene out of contact with air decomposes at about 770 degrees C. into its elements. Berthelot and Vieille have since found that this decomposition, at a pressure above 2 atmospheres, takes place throughout the entire volume when it takes place at a point. This decomposition, which takes place with increase of pressure, can be effected either by the heating of a point on the wall of the recipient to the required temperature or by means of a platinum wire carried to a red heat by an electric current, by an electric discharge between two electrodes, or by the explosion of a fulminate cap in the compressed gas. The experiments for the obtaining of acetylene black at low pressures have been undertaken by Berger and Wirth, of Leipzig. They show that this gas can be decomposed under these conditions by the sparks from an electric induction coil. The question of the proper form to give to the apparatus is beset with difficulties, because continuous working is possible only when the black formed by one spark is immediately removed and replaced by fresh gas. Black is also obtained by passing acetylene through incandescent tubes (Berthelot), although the industrial application of such a process would be hindered by the formation of graphite obstructions in the tubes.

The experiments of Berthelot and Vieille, made in 1896, upon compressed acetylene, appeared at first sight to offer more chance of success, because an initial explosion decomposed in an instant the entire volume of gas. This was commented upon by Hubou, who estimated that in this decomposition of acetylene compressed to 2 or 3 atmospheres a pressure of over 25 atmospheres was produced, a pressure that could be provided against by means of an appropriate recipient. Under these conditions the decomposition into carbon and hydrogen is rapidly effected. Hubou recommends steel cylinders capable of resisting 200 atmospheres pressure for the recipients. Flasks of this kind present difficulties in opening and emptying, and it would seem preferable to employ large boilers or chambers accessible by a manhole, as has been proposed by several.

With reference to the pressure which exists during the decomposition, the results of Hubou agree approximately with those which Gerdes has made in verifying the work of Berthelot and Vieille, according to which the pressure should increase to 7·5 times the initial pressure. Therefore, if acetylene under three atmospheres is used, a resulting pressure of 25 atmospheres can be counted upon, and the recipients should be tested to between 40 and 50 atmospheres. Among the means proposed for effecting the explosion, those which heat the cylinder up to the required temperature should be excluded, as they weaken the cylinder, although they were used in the tests made by Pintsch. On the contrary, nothing seems to discourage the use of an electric current or an explosive cap. It is evident that

*Translated by The Progressive Age from the Journal du Gaz et de l'Electricite (July 31) and the Chronique Industriel. The author is doctor of sciences and senior "preparateur de chimie" at the Ecole Polytechnique.

in the construction of apparatus which can be used for the purpose great technical difficulties are always met with, and the question presents itself whether the expense of such a plant is not out of proportion to the superior advantages gained. Such apparatus should also have a considerable volume on account of the enormous space occupied by the flocculent acetylene black formed.

The use of acetylene already permits the preparation of various kinds of black. Thus, Berger and Wirth have obtained by the combustion of mixtures of acetylene with coal gas in variable proportions kinds of black which vary in their properties from the best coal gas black to pure acetylene black.

Finally, there remains but to mention the methods proposed to obtain acetylene black by chemical means. Subsequent to the announcement of Moissan and Moureu acetylene was passed through finely divided metal, such as spongy platinum, reduced iron, etc., by Ludwig, working at ordinary temperatures, resulting in the separation of hydrogen and the deposit of carbon. The action of chlorine upon acetylene has also been experimented with. The results of these two methods, from an economical point of view, have not been encouraging. The best part, however, of the actually serious tests that have been made have been in the direction of decomposing acetylene directly into carbon and hydrogen.

THE UGANDA RAILWAY.

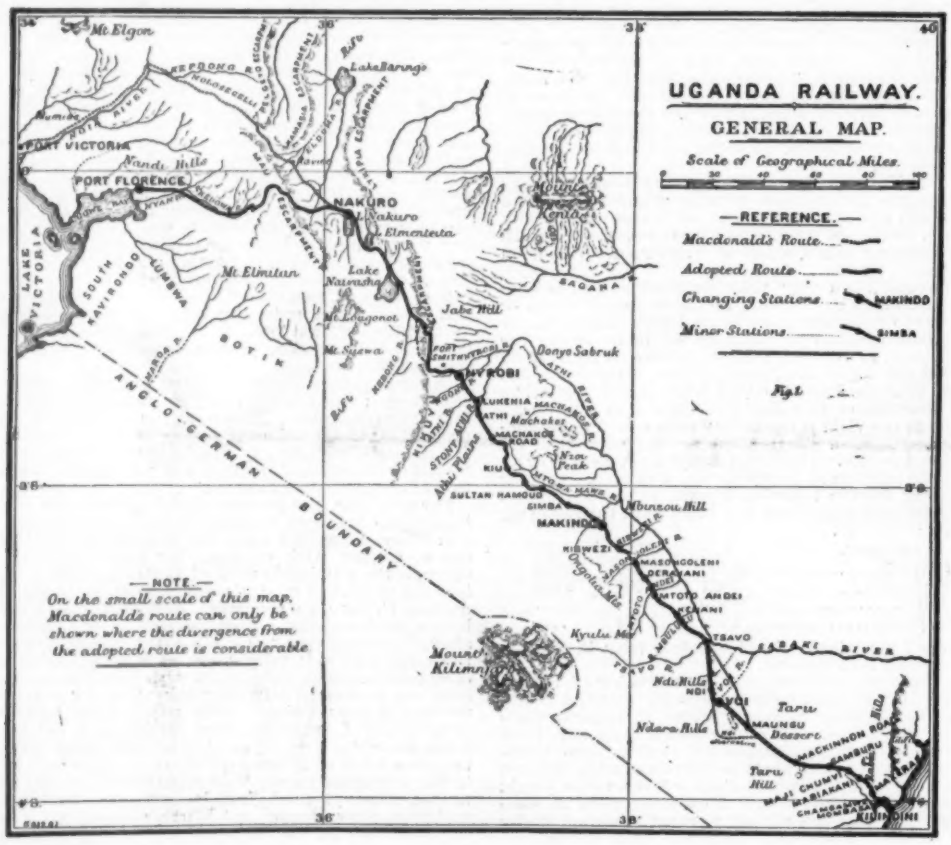
IT is really remarkable that the British Treasury, with its pedantic methods of doing business, was ever induced to sanction the construction of the Uganda Railway, considering how scanty and doubtful were the data on which the estimate was formed. From a perusal of maps and books of travel, Sir Guilford Molesworth, Sir John Fowler, and General Williams, each made a report, the first putting the cost at £2,700 a mile, the second at £3,166, and the last at £3,400. A survey expedition was then authorized, and started under Captain (now Major) Macdonald, in November, 1891. A map was made, and a line laid down, but as the expedition was tied to the caravan route by the density of the jungle and the difficulties of transport, and had only a restricted sum to spend, it was unable to make a detailed examination of the ground. An estimate was framed on the result of the survey, and an average cost of £3,422 per mile was assumed. Against this we may set the amount expended on the railway up to the end of October, 1898, which was, in round numbers, £1,038,600. At that date the railhead had reached the 225th mile. In a report *, recently issued, Sir Guilford Molesworth allocates the expenditure to different heads of account as follows:

	Per Mile.
Administration	£ 479
Surveys	167
Land	43
Earthworks	896
Bridges and culverts	324
Fencing, etc.	12
Telegraph	117
Ballast and permanent way	1,334
Stations and buildings	379
Rolling stock	697
Plant	106
Ferries, etc.	43
	£4,596

The line up to the 225th mile was unfinished, and expenditure will be required to complete the permanent line in those parts where temporary diversions are still used. On the other hand, much of the expenditure now allotted to these 225 miles will have to be divided over the total length of the railway when completed. A new and much shorter route has also been discovered for the western section, so that it is still possible that the aggregate estimate may not be greatly exceeded, although the cost per mile will be much beyond that anticipated. The greater portion of the expenses of the survey has been due to the determination of the most favorable route for adoption over the escarpments (see map). The setting out has already reached the 418th mile. The works on the escarpment will, of course, be more expensive than those on the first 225 miles. The two escarpments which the line has to cross have greatly added to its cost, and to the difficulties of the engineers. The line climbs from the level of the Indian Ocean to a height of about 7,700 feet at the Kikuyu escarpment; it then drops irregularly to 6,000 feet only to climb again to 8,330 feet over the Mau escarpment. Between the two summits lies the great meridional rift, which has an average width of 25 to 30 miles, and extends north and south considerably beyond the limits of British territory. The floor of the rift is by no means level; but rises from the south at a gradual slope, to the saddle at Longonot, near Lake Naivasha. After several undulations at Lake Naivasha, Elmenteita, and Nakuro, it slopes downward again to the north past Lake Baringo. The two great volcanoes, Longonot and Suswa, with numerous smaller cones and irregularities, rise from the floor of the rift, and all the lakes are manifestly of volcanic origin. On one side of the rift is the Mau escarpment, and on the other side the Kikuyu escarpment, rising to an elevation of from 8,000 feet to 10,000 feet, the crest being 2,000 feet to 3,000 above the floor of the rift. From the summit of Mau the line drops to Lake Victoria, which is merely 4,000 feet above sea level.

The map shows the general route, which, it will be seen, follows the left side of the valley of the Sabaki River from the 128th mile at Tsavo to Nyrobi at the foot of the first escarpment. The line starts from Kilindini on the island of Mombasa, and immediately crosses an arm of the sea on a steel bridge. It then climbs the Rabai hills, there being some heavy work. There the railway runs along the divide between the watersheds, thus avoiding the cross drainage and the ravines. From Mazeras (13¼ miles) the line is fairly easy, but the ruling gradient (1 in 60) and the minimum curve had to be freely used in order to avoid heavy work and expense. At 50 miles the line enters the Taru desert, and more nearly approaches a surface line. The chief work here was the clearing of the dense thorny jungle and the grubbing up of the stumps. The jungle would not burn readily, and an extra width had to be cleared to allow the timber to be drawn clear of the track.

Owing to a peculiarity of the foliage, the country, with few exceptions, affords no shelter from the sun. In spite of the closeness of the jungle there are no shade trees, and the only effect of the jungle is to shut out any breeze. The Taru desert extends as far as Tsavo (132 miles), but beyond Voi the features of the country admit of a ruling gradient of 1 to 66. At mile 132 the Tsavo River is crossed, and thence to mile 162 the railway presents no great difficulty. From mile 152 to mile 193 (Kibwezi) the work is very heavy, and there are several considerable bridges. After Kibwezi the work is again easy, with the exception of the bridges on the Kiboko, Kifaro, and Simba Rivers to about mile 258, where the country becomes very broken to about mile 280. The line here follows the valley of the Mtowa-mawe, which breaks up into numerous ravines of no great depth, with precipitous sides and sandy bottoms, in which water holes are found at rare intervals. These ravines involve heavy work. From this point (mile 258) to Nyrobi (mile 326) the work is comparatively light with the exceptions of the crossings of the Stony Athi, Athi, and Ngongi Rivers.



* Africa. No. 5. (1899.) Report on the Uganda Railway, by Sir Guilford Molesworth, K.C.I.E., dated March 28, 1899. With six maps. Presented to both Houses of Parliament, June, 1899. Eyre and Spottiswoode. [1s. 3d.]

Nyrobi will be made the headquarters of the line with the locomotive sheds and repairing shops. It stands at the foot of the ascent to the first escarpment. The character of the country here changes abruptly; a sloping upland, well-wooded, cultivated, and densely populated, takes the place of the dry, undulating Athi desert. This upland is much broken up by spurs running out from the backbone of the Kikuyu escarpment, alternating with ravines, which increase in depth further to the north. The line follows one of these spurs beyond Fort Smith, where it gains distance by development, and crosses to a parallel spur near Zuwani (mile 339). Here the line strikes the north, debouching finally from the spur into a valley where forest alternates with open grass land. This valley is followed till the summit of the escarpment is reached at an elevation of upward of 7,800 feet. After reaching the summit the line turns abruptly to the south and develops round a valley, curving northeast again to a broad flat shelf, which forms the first step of the escarpment. From this point a temporary rope incline is to be constructed to reach the bottom of the rift at once, so that a temporary diversion can be pushed on rapidly from its foot up the floor of the rift during the construction of the permanent line. The latter descends the escarpment with easier grades, but heavier works, and joins the temporary line again about two miles short of the Longonot saddle. The ruling gradient on this section is 1 in 50.

The line has not been staked out for a great distance beyond the saddle. The chief engineer, Mr. George Whitehouse, M. Inst. C.E., proposes to ascend the Mau escarpment almost at once, reaching a summit level of about 8,330 feet; and to descend to Lake Victoria by the valley of one of the tributaries of the Nyando River. This will effect a saving in distance of more than 100 miles, when compared with the route via the Eldoma Ravine and the Nzoca River set out by Major Macdonald. This officer's proposed route is shown in dotted lines on the maps. Beyond Mau it is impossible to speak with certainty as to the details of the country until the survey is further advanced. Generally speaking, the proposed line falls at first steeply from the summit, the greatest engineering difficulty being the descent into the valley of the Kedowa River. In the last 25 to 30 miles to the lake the fall is very slight. Port Florence, in Ugowe Bay, selected by the chief engineer as the lake terminus of the line, appears to possess great advantages, affording shelter from the prevailing winds, and having sufficient depth of water.

The Uganda Committee, who have the oversight of the railway, felt considerable disappointment at its slow progress. Operations were commenced in 1895, and on February 1, 1898, the first section was opened for traffic. In October, 1898, the Committee wrote to Sir G. Molesworth, "From the latest information in the hands of the Committee the line. . . . has now advanced so that the railhead is at 225 miles, that 130 miles have been staked out, and a certain amount of preliminary earthwork has been executed. . . . The work has now been in progress in Africa for nearly three years, and only one-third of the estimated length of line has been completed. The object of Sir G. Molesworth's visit was, in the main, to see if this rate of progress could be accelerated, it being suggested to him that possibly the management might be at fault. In his report Sir Guilford entirely exonerates the chief engineer and the staff, and when we read the long list of difficulties they had to contend against, we can only admire the great progress they made in spite of them. It must be remembered that the country is entirely new in a very different sense from that in which the American prairies and the Canadian forests are so described. We fancy the surveying parties must often have defined it in other and more forcible fashion. It is close to the Equator, and very ill adapted for the residence of white men. For 250 miles from the coast the tsetse fly abounds, and there it was almost impossible to keep beast of burden alive. Camels, mules, and donkeys died rapidly, and long before they succumbed they were too weak to be of any practical use. Formerly everything was carried on the heads of porters, but that is a form of transport which is not practicable for the building of a railway. Over the first hundred miles of line water is very scarce, and what can be found is generally bad. Again from mile 131 to mile 310 there is no reliable source from which water can be obtained. The supplies are scanty and often unwholesome, and generally unsuitable for locomotive use. Special water trains were necessary to supply the working parties. For the maintenance gangs, 43 tons of water were required per diem in December, and this water had to be hauled an average distance of 58 miles. For the railhead parties 68 tons of water were required daily, besides that wanted for the constructors' parties, the medical officers' camp, and the two assistant engineers' camps.

For all practical purposes, a great part of the country was uninhabited. The natives had no idea of continuous work, and had no food to dispose of, so that they were perfectly useless. Nearly all the labor had to be imported from India, as many as 13,000 coolies being employed at one time. These had to be paid relatively high rates, to be fed, and to be nursed when ill. Rations for the whole of them had to be sent up from the coast, the daily weight required being 21 tons last December. Practically there was an army of 15,000 men, in an almost waterless country, devoid of all resources and of all means of animal and wheeled transport. The distance of the most advanced parties at the date of the report was 400 miles from the base, and even at the base everything had to be imported from a distant country. From railhead to the advanced parties all stores had to be carried on the heads of porters, who had, in addition, to carry their own food. Further there were epidemics of fever, fears of the plague, and a very serious incursion of lions, who carried off some 28 men in all, and created a feeling of insecurity which caused much trouble and delay. All supplies were limited by the facilities for unloading at Kilindini, where only one steamer of 7,000 tons could be conveniently dealt with per month.

Delay was caused by want of an adequate number of locomotives. In the first instance this was due to the engineering strike, and afterward by the great press of work in the locomotive shops. Engines were ordered from America, and some second-hand metergage locomotives procured from India, but not suffi-

cient for the needs of the line. These were great on account of the numerous temporary diversions with grades of 1 in 30, and curves of 400 feet radius, which were put in to allow the line to be pushed on past heavy earth works. The number of engines in the sheds was also great, as the water was mostly bad, and the boilers had to be washed out very frequently; in addition the repairs were heavy owing to derailments and to the wear of tires on the sharp curves.

In concluding, Sir Guilford Molesworth (to whose report we are indebted for the maps and section, and for much of our information) says, "Taking into consideration the difficulties I have enumerated, I am of opinion that the rate of construction has, on the whole, been maintained in a manner highly creditable to the chief engineer and the officers concerned. . . . Of the survey and setting out I cannot speak too highly. Involving, as they have done, the examination and traversing of numerous alternative lines in difficult country, they have resulted in a wonderfully easy line, considering the broken character of the ground."

From a later report* we learn that 155 miles were staked out from March 31, 1898, to the same date of 1899, carrying the permanent alignment to mile 418; that is, the center of the rift. Three survey parties are now employed on the remaining 137 miles or so, yet requiring to be finally aligned; one working from the 418th mile toward Lake Nakuro, and the other two working from the summit of the Mau range, one eastward toward Nakuro, and the other westward toward Port Florence. So far as these surveys have progressed, no formidable difficulties have been encountered. The distance remaining to be surveyed is now about 75 miles. By a wise provision a strip of land, one mile wide, is being reserved on either side of the line as an asset of the railway, where such land is unoccupied. During the year ending March 31, 1899, the rails were laid from mile 139 to mile 279, an advance of 140, as compared with 98 miles in 1897-8. When Sundays and the various holidays observed by natives of India are allowed for, this amount shows an average rate of progress of half a mile per working day. For purposes of transport two traction engines of a special description, with trains of wagons, have been imported. These proved most effective for distances not exceeding 25 miles beyond the rails, in carrying heavy weights, such as bridge girders, cement and similar material. These engines also allow large gangs of laborers to be put to work further in advance of the rails than had hitherto been possible, the regular supply of food, and in many cases of water, being the governing factor which regulates the employment of large bodies of men in the districts passed through. Two more of the traction engine trains are being supplied.

The first length of [illegible] miles to Voi Station was opened for goods traffic on December [illegible] 1897, and for passengers on February 1, 1898. Successive portions were opened during the year 1898 as follows:

FOR GOODS.

To mile 120 ..	April 9.
" 131 .	May 14.
" 162...	June 18.
" 182	August 20.
" 207.....	October 1.
" 227	November 5.

FOR PASSENGERS.

To mile 101.....	February 14.
" 132	June 2.
" 162.....	July 4.
" 207.....	October 24.

—Engineering.

*Africa, No. 6. Eyre and Spottiswoode. [Price 3½d.]

THE DORTMUND-EMS CANAL.

THE Dortmund-Ems Canal, which was officially opened by the Kaiser on August 11, is the culmination of a plan first projected more than two centuries ago. Friedrich Wilhelm, der grosse Kurfürst (the great electorate prince) saw the importance of such a waterway, and Frederick the Great, when he made Emden a free port, promised to carry out the plan in the treaty of 1744.

The canal, which in size surpasses all previously constructed European inland waterways, is a noteworthy piece of engineering. Its length is 270 kilometers (167·67 miles), its depth 2·5 meters (8·2 feet), its breadth at the surface of the water 30 meters (98·40 feet), and at the bottom 18 meters (59·04 feet). Its cost was 69,450,000 M. ($17,362,500), of which part was paid by the city of Dortmund. The comparatively few inequalities in the region through which the canal passed, and the fact that the bends in the river from Meppen to Herbrun have been cut through so as to shorten the trip on the river, considerably simplified the work.

Starting at the harbors of Dortmund, which were built at a cost of 6,750,000 M. ($1,687,500), of which 1,325,000 M. ($341,250) were appropriated by the city, the canal runs in a northwest direction to Meckinghoven, situated somewhat to the north of Henrichenburg. Upon this first portion of the canal are two small harbors or basins, of which there are forty-two along the line of the canal, capable of affording accommodation for as many as six vessels each.

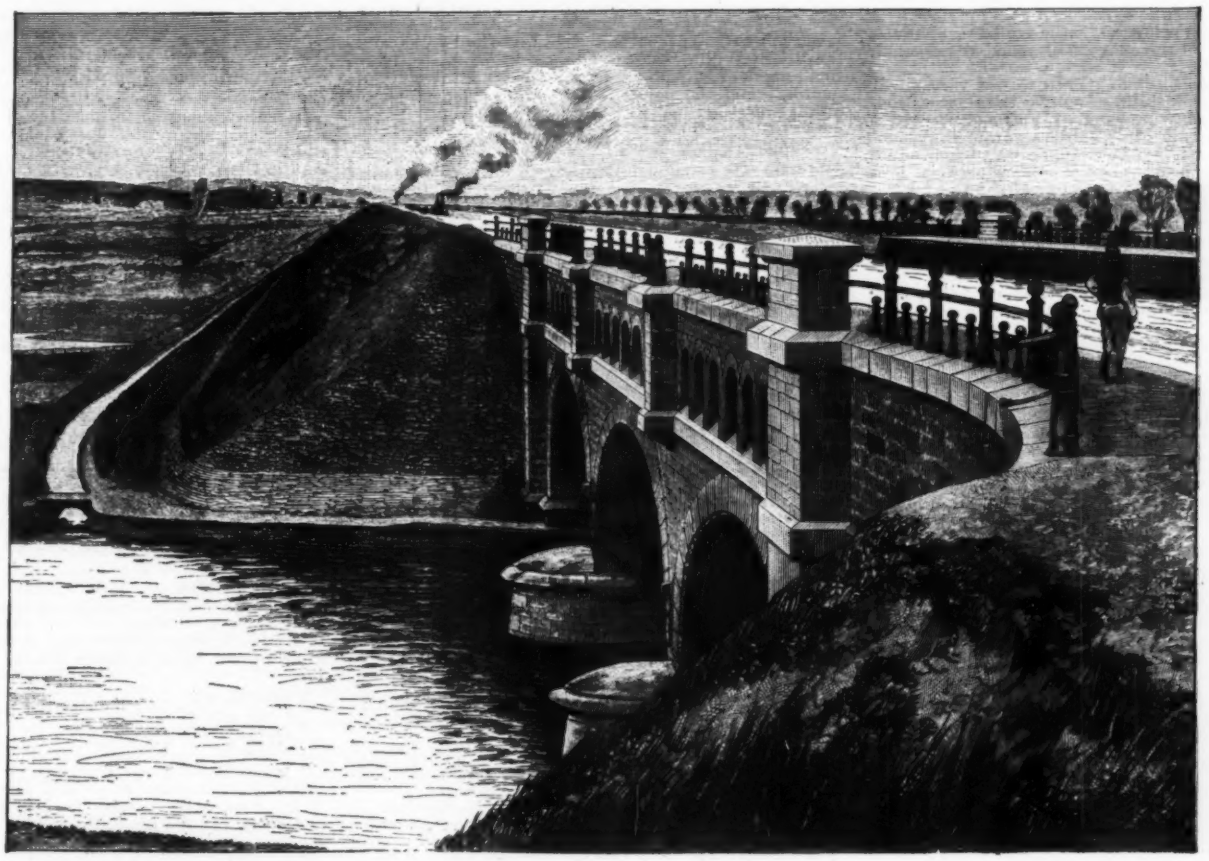
At Henrichenburg a huge lift-lock has been constructed, which is probably the largest of its kind in the world. The water-tank of the lock is suspended in a bridge-like structure supported by trestle work resting on five floats, which rise and fall in water-filled wells. The load of the water-tank and vessel (3,000 tons) is equally distributed on the floats. The addition or subtraction of a small weight of water is sufficient to raise or lower the entire sytem. This small weight of water is easily obtained by stopping the tank slightly below the upper level, so that the water can run into the tank. When somewhat above the lower level, the tank is arrested so that the water can run out. By this simple method of operation, the lock-chamber can be raised without great expenditure of power. At each end the chamber is closed by a vertically-movable door, through which the vessels pass in and out. In order to control the movement of the water-tank, to keep it in horizontal position, and at the same time to prevent accidents, four screw-spindles are employed which are synchronously turned by an electric motor through the medium of gearing. The motor is of such power that it is capable of raising and lowering a vessel without the addition or subtraction of water. The other moving parts of the lock are likewise electrically operated.

After leaving Henrichenburg, the canal changes its course to the northeast, its elevation above the North Sea being 183·68 feet. On its way to Münster the canal crosses the rivers Lippe and Stever by means of two bridges, the first of which rests on three 70-ft. arches, and the second on three 40-ft. arches. One of these bridges is shown in our engraving, reproduced from Illustrirte Zeitung.

At Münster the boats are lowered to the next level by two locks. Of these locks there are twenty-two along the line of the canal, which vary from 219·76 feet to 541·20 feet in length.

After the government had constructed the canal, it remained for the various cities and communities to complete the work. The larger cities, such as Emden, Leer, Papenaburg, Münster, built wharves and made such general improvements as seemed necessary. At Dortmund the basins have been so constructed that they can be enlarged as the needs of the growing city may require. Near the iron works of the Dortmund Union, no less than 400 acres have been reserved for harbor purposes.

The importance of this new canal can hardly be overestimated, for it connects the great industries of Western Prussia with the sea. For the Westphalian coal mines this new means of transportation was almost a necessity. During the period of 1880–1884, from 22,500,000 to 28,500,000 tons of coal were mined in Westphalia, and the number of men employed rose from 80,152 to 103,626. Since that period the coal mines have vastly increased their output. In 1897, 48,500,000 tons were mined, and the number of men employed was 185,000. The cost of transporting this enormous quantity of coal by rail was so great that the sea-coast factories found it cheaper to use English coal, and the Westphalian miners had great difficulty in selling their products profitably. It was, therefore, necessary to provide some means to enable Westphalian coal to compete with that of England. And the means whereby German miners have attained this end is the Dortmund-Ems Canal.



THE CANAL-BRIDGE ACROSS THE STEVER NEAR OLFEN.

STEAMSHIP LINES TO THE HAWAIIAN ISLANDS.

THE fact that the Hawaiian Islands are now in the possession of the United States of America gives them an importance which hitherto they did not possess; and it is, therefore, necessary to note any circumstances which affect their trade and their connections with other countries. From a dispatch recently received at the Foreign Office from the acting British consul at Honolulu, we learn about the arrival in that port, on her way to San Francisco, of the "Nippon Maru," the first of three steamers belonging to the new Japanese Mail Steamship Line, which are to run between Hong Kong (via China and Japan ports) and San Francisco, in a joint service with six steamers (three each) of the Pacific Mail and the Occidental and Oriental Steamship Companies, which now carry on the service. The "Nippon Maru" (as well as the other two vessels, the "Hong Kong Maru" and the "America Maru") was built in Scotland last year, and compares very favorably, both in size, accommodation, and speed, with the vessels of the other two lines. She is commanded by an English master, and is officered by English and Japanese, the former preponderating and holding the positions of trust and responsibility on board. The Pacific Mail Steamship Company is American, and has three vessels on the line, one of which was built in England. Two new and improved steamers are about to be built in America to replace two of the existing ships, and all three will thus be American built and owned and under the United States flag. The Occidental and Oriental Steamship Company has three vessels on the route, which are chartered in America from the White Star Line, and which fly the British flag. These two lines have the same agents in Honolulu, in Yokohama, and in Hong Kong, and their steamers have hitherto run in alternation and conjunction. Another line—the Oceanic Steamship Company—has three steamers calling at Honolulu on the way to and from San Francisco and Australia. Two of its vessels are under the American and one under the British flag, and the company has been in receipt of a subsidy from the New Zealand government of $150,000 a year for over twenty years. The above list of twelve vessels comprises all the regular mail and passenger steamers which call at Hono-

lulu at present on their way to and from San Francisco. In addition there is a British line of three steamers belonging to the Canadian and Australasian Royal Mail Steamship Company, which runs monthly between Victoria, British Columbia, and Sydney, calling at the Hawaiian Islands, Samoa, and Fiji on the way. In view of the fact that the Americans are seeking to develop their trade with China, and that Hawaii is a half-way house between San Francisco and China, we may take it for granted that the steamship communication with the Hawaiian Islands will rapidly increase in importance.—The Engineer.

THE CAPACITY OF ALUMINUM IN LITHOGRAPHIC PRINTING AND DRAWING.

By E. F. WAGNER.

THAT the new method in lithographic printing is exerting a powerful influence throughout the country we have had ample opportunity to observe in our travels. We have been questioned on many sides, and many letters have been sent to us on the subject. From these letters we pick out one from the Province of Ontario as touching all the vital points of the question before us, and we therefore answer as fully as space will permit. The questions are as follows:

1. What success has been attained by drawing in crayon direct upon aluminum on very fine, small work?

Ans.—With proper care a skilled penman or crayon artist can do work on aluminum plate which is just as fine as can be done on stone, and a considerable proportion of such drawing is now done in New York on aluminum. Even engraving and ruling of fine lines can be executed. Only the etching, through a resistive ground, presents difficulties, on account of the uneven corrosion of the metal by the particular acids which have to be employed.

2. In a five to ten color job, is the registration affected by the action of the changes of temperature upon the aluminum plates?

Ans.—The changes of temperature are very slight on this metal in the printing room, as the thermal condition must be properly watched in a room where five to ten color work is printed, above all other things.

3. For label work, can the same solidity, depth and brilliancy of color be obtained from aluminum, as now produced from stone, with the same amount of ink?

Ans.—On label and general chromo work the same solidity, depth and brilliancy of color can be obtained from aluminum as is produced from stone, with even, as it is claimed by some printers, a less amount of ink and a reduced amount of damping. Of course, printers do not all understand the method as yet, and the result is that quite a proportion of the work done from the plate is poor. Still in no case is it as poor as some work done from stone.

4. Do aluminum plates work satisfactorily on commercial work?

Ans.—If the proper amount of pressure can be brought to bear through the construction of the press used, then pretty fair results can be obtained on commercial work, but if the pressure lacks (the work being flat on the plate) the impression is not as clear, full and rich as from a stone on which the commercial work has been etched above the surface. This is owing to the impossibility of etching aluminum as easily as stone.

5. Can changes be made on the aluminum plate after the drawing has been rolled up as well as on stone?

Ans.—Changes can be made on the aluminum plate after the work is rolled up and etched, but not as easily as on stone or zinc, counter-etching being an uncertain operation in aluminum.

6. Is the process of printing from aluminum controlled by any one? If so, from whom is it to be obtained and what is the outlay to install it?

Ans.—Yes, the process has been patented, and is controlled by an international corporation, Fuchs & Lang Manufacturing Company, 29 Warren Street, New York, being selling agents. The royalty for its use is $150 per press. The metal is sold in the unprepared state at one-half cent per square inch, and tanks and graining apparatus, as well as iron beds for the flat bed presses, must be added to successfully work it—all furnished by the above named company or any of the aluminum printing machine builders.

In conclusion we would add a few general remarks adapting themselves to the foregoing questions and answers.

Large poster and theatrical work is now drawn first on aluminum and other prepared plates, and the artists find it much more pleasant to handle, besides being more easily adjusted than stone in the modern rotary presses.

A large aluminum or other litho-metal plate should not be brought in from a cold store-room to a warm work-room, as that affects its size, although only a trifle; it also tends to interfere with the chemical process operating on the plate during drawing or printing.

In bronze work the sheets must be brushed very clean, and no particles of bronze must be floating about the room, for when they settle upon the plate they will stick and take ink.

If commercial work is to be done, it had better be made a specialty of, as hands and presses can seldom be trained to do both in the same course.

Regarding the drawing of originals for very small work, especially where much scraping and printing is to be done, stone is always the best. The service of metal plates in surface printing in the steam press is for more economical printing. The highest class of fine art work better be left to stone: in fact, no lithographic establishment can get along without a certain quantity of the latter.

The principle of printing from metal plates, aluminum or zinc, is the same as from stone. The only basis the patent has to rest upon is the fact that there is a difference in the nature of aluminum as compared with common zinc, which renders the former much less liable to oxidation and therefore holds a design clearer, sharper and longer during the printing processes.—Aluminum World.

The University of California is going to introduce a two years' "diplomatic" course which will give students an opportunity of acquiring special knowledge necessary for entrance into diplomatic and consular service.

MISCELLANEOUS NOTES.

The Elek. Zeit. recently stated that two Parsons steam turbo-dynamos, each of 1,000 kw., have just been completed, and will be started at the end of this year in the new central station in Elberfeld, Germany. The four-pole alternators have drum armatures, and make 1,500 revolutions per minute, the voltage at the poles being 4,000.—Electrical World.

The Bruay Colliery Company has contracted with the Société Française de Forage, which works under the Raky patents, to put down a borehole 1,200 meters deep, at Houdain, in the Pas-de-Calais, the first half of the depth being bored with rigid rods and Fauvelle water injection, while for the remainder the diamond drill will be used, so as to permit of bringing up cores, or actual samples, of the rocks passed through. The hole was begun with a diameter of 24 centimeters; and in the chalk as much as 50 meters could have been bored daily if the pump had been powerful enough, says The Engineering and Mining Journal. The Houdain hole, which reached the Devonian at the depth of 280 meters, is only proceeding at the rate of 3 or 4 meters daily, the rock being excessively hard.

The restoration of the Thames and Severn Canal has proved a more difficult and troublesome business than was anticipated. This waterway is seven or eight and thirty miles long, and all but about four miles of it had fallen out of use, and had gone more or less to decay. To restore it to a navigable condition about $100,000 was borrowed, and after three years of steady work the canal was so far restored that boats actually made the passage from the Stroud Canal at Wallbridge to Lechlade on the Thames—the whole length of the waterway. The work, however, has not proved so complete as it was supposed to be. The canal has developed leaks at several places, and the water has had to be drained off and the puddling resumed. In the thirty-seven miles there are no less than forty-four locks, and this division of the famous waterway into comparatively small sections will no doubt minimize the difficulty of making good the defects. There seems no reason to doubt that the canal will be made sound, but in the meantime, of course, there is no through passage, and the summer's trade is lost.—Mechanical Engineer.

Messrs. De Dion and Bouton, of Puteaux, France, are having built in Paris a new "body" for a twenty-four seated steam omnibus entirely constructed of partinium. Partinium is used very largely by motor car builders in France in place of aluminum, it being very much cheaper than this metal, is nearly as light, and possesses greater resistive qualities. Partinium is, as a matter of fact, an alloy of aluminum and tungsten, the percentage of each being varied as desired. Cast partinium has a specific gravity of 2·89; in the rolled form it is 3·09, the elongation varying from 6 to 8 per cent., while its tractive resistance is given as 32 to 37 kilogrammes per square millimeter. It is interesting to note that the "body" of M. Jenatzy's well-known record making car, "La Jamais Contente," is constructed of the new alloy, which is being employed for a variety of other purposes by automobile builders on the Continent. Messrs. De Dion and Bouton are using it to a large extent both for the oil containing crank-case in their tricycle motors and for gear cases in their large steam vehicles. It is satisfactory to note that the advantages of the new alloy are receiving the attention of motor car builders in this country.—Industries and Iron.

The great changes which have occurred in the railway system of the United States in a comparatively few years are shown by the following statistics, taken from Poor's Manual:

	1880.	1898.	Per cent.
Miles of railway	93,262	186,810	Inc. 100
Miles of track	115,647	245,239	Inc. 112
Miles of steel rails	33,680	220,804	Inc. 555
Miles of iron rails	81,967	24,435	Dec. 70
Number of locomotives	17,949	36,746	Inc. 104
Number of passenger cars	12,789	25,844	Inc. 102
Number of freight cars	539,255	1,284,807	Inc. 138

"While the miles of lines have doubled the miles of track have increased 112 per cent., showing a greater proportion of sidings and supplemental tracks," says The Railway Age. "There are five and one-half times as many miles of steel rails as in 1880, while the mileage of iron rails has decreased 70 per cent., to a little over 24,000, and will soon disappear entirely. The number of locomotives and cars has much more than doubled, but this gives no idea of the vast increase of capacity that has been effected by increasing the weight of engines and the size of cars. In these respects, especially, the last eighteen years have witnessed a marvelous advance on American railways."

A ship canal across the Maryland and Delaware peninsula must be built, says The Baltimore American. The time has arrived when something must be done to protect Baltimore's export trade from the inroads being made upon it by ports further south, and this ship canal offers the only possible solution of this problem. The American fathered this project and urged its importance to the city and to the state because it was convinced that such a waterway was absolutely necessary for the protection of the commerce of this port, for keeping Baltimore ahead of her rivals in the hot competition for the great export trade from the eastern seaboard. There is no use hiding the facts any longer. Newport News, only a short distance to the south of us, is being built up as a port of shipment at the expense of Baltimore, and its marvelous growth will continue unless Baltimore shortens her distance to the great ports of foreign lands. Other southern ports clear down the coast, even to New Orleans, are gaining some of the commerce that should come here. The canal can be built for $10,000,000. Councilman Sprosser proposes to send a memorial to congress, and if that body consents to build it as a national enterprise, which it would be, well and good. Efforts in this direction before have failed, and if the government will not undertake the work the state of Maryland and the city of Baltimore must build it. The state is rich, and a loan for $10,000,000 could be floated at a very low rate of interest. Chicago has been spending over $50,000,000 for only a drainage canal, while New York stands ready to spend $200,000,000 on its state waterways. Maryland can certainly afford to spend $10,000,000 on the ship canal.

SELECTED FORMULÆ.

Some Useful Photographic Formulæ.—

THE COMBINED REDUCER AND INTENSIFIER.

Potassium bromide	120	grains.
Cupric sulphate	250	"
Distilled water	q. s. ad 10	ounces.

Label: For intensification immerse the well washed negative in the solution till bleached, then rinse well and redevelop. For reduction immerse the negative in the solution till bleached slightly and then refix; the longer the negative is allowed to remain in the solution the greater the reduction. Price, 25 cents.

THE SILVER INTENSIFIER.

1. Mercuric chloride	100	grains.
Ammonium chloride	100	"
Distilled water	q. s. ad 10	ounces.
2. Silver nitrate	100	grains.
Potassium cyanide	q. s. or 100	"
Distilled water	q. s. ad 10	ounces.

To make solution No. 2 dissolve the silver in half the water and the cyanide in the remainder; add the latter to the silver, gradually shaking between each addition until the white precipitate first formed is nearly all redissolved, and then make the total bulk to 10 ounces.

Label: Poison. The negative must be thoroughly freed from hypo, and then immersed in No. 1 till bleached right through; and again wash and immerse in No. 2 till blackened, and again wash. Price, 60 cents.

ONE SOLUTION REDUCER.

Sodium sulphite	180	grains.
Potassium ferric oxalate	½	ounce.
Distilled water	q. s. ad 10	"

Dissolve and add

Oxalic acid (crystals)	30	grains.

Shake till the solution turns green, then pour off from any undissolved acid, and add

Sodium hyposulphite	2½	ounces.
Water	q. s. to make 20	ounces in all.

Label: Immerse the negative in the solution and remove just before the desired reduction is obtained, and then wash thoroughly. This solution must be kept in the dark, and can be repeatedly used, or until it turns yellow. Price, 25 cents.

ONE SOLUTION REDUCER.

Potassium iodide	40	grains.
Sodium hyposulphite	2	ounces.
Distilled water to	10	"

Label: This reducer acts slowly, and may be used for plates and papers. After use the negative should be well washed. Price, 25 cents.

ORDINARY NEGATIVE VARNISH.

Gum sandarac	1	ounce.
Orange shellac	½	"
Castor oil	90	minims.
Methyl alcohol	1	pint.

Allow to stand with occasional agitation till dissolved, and then filter.

Label: The negative should be heated before a fire till it can be comfortably borne on the back of the hand, and then the varnish flowed over, any excess being drained off, and the negative should then be again placed near the fire to dry. Price, 60 cents.—Pharmaceutical Journal.

Laundry Polish.—1. Melt 5 parts of stearic acid, add 5 parts of absolute alcohol, and triturate the mixture with 95 parts of wheat starch. Starch prepared with this mixture takes easily a fine polish. The polishing irons should be thoroughly cleaned immediately after use.

2. Spermaceti	1¾	ounces.
Gum arabic	1¾	"
Borax	1¾	"
Glycerin	4½	"
Distilled water	1½	pints.

Boil half the water and add the borax and spermaceti to it. Separately dissolve the gum in the remainder of the water and the glycerin. Strain and mix thoroughly with the warm mixture. This is a good gloss for cold water starch; a wine glass of it is used with 4 ounces of dry starch.

3. White wax	2	ounces.
Spermaceti	4	"
Stearin	½	"
Ultramarine blue	3	grains.

Melt together and let cool.

For doing up a dozen shirts, put a piece the size of a hazelnut in the hot starch, and mix. The boiling water serves to emulsify the waxy substance of the mixture. Finish with a hot iron, the usual way.

STARCH POLISH.

Spermaceti	1 ounce.
Borax	1 "
Starch	4 "

Reduce the spermaceti to fine powder by the aid of a little alcohol, and mix with the powdered borax and starch.—Pharmaceutical Era.

The new transfer paper, known as "décalque rapide," invented by J. B. Duramy, consists of a paper of the kind generally used for making pottery transfers, but coated with a mixture of gum and arrowroot solutions, in the proportion of 2½ parts of the latter to 100 of the former. The coating is applied in the ordinary manner, but the paper is only semi-glazed. Furthermore, to decorate pottery ware by means of this new transfer paper, there is no need to immerse the ware in a bath in order to get the paper to draw off, as it will come away when moistened with a damp sponge, after having been in position for less than five minutes, whereas the ordinary papers require a much longer time.—Pottery Gazette.

A French magazine, devoted to the clockmaking trade, gives the following process for restoring nickel, and the majority of metals subject to tarnish, to their original color: Dissolve 0·40 to 0·45 gramme of cyanide of potassium in half a glass of water, plunge the objects into this solution and withdraw them immediately. A simple rinsing with water suffices to remove every trace of acid. Next plunge them in spirit of wine and dry them in sawdust to preserve from rust.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Westinghouse Air Brakes on Russian Railways.—Consul-General Holloway, of St. Petersburg, under date of July 27, 1899, writes:

In transmitting the translation of the ministerial order requiring all standard Russian railways to equip their freight cars and engines with the Westinghouse air brakes by January 1, 1903, at a cost of several million rubles (this order provides that the introduction of other systems of continuous automatic brakes will only be allowed after a trial of three years), I desire to state that the Westinghouse Company has erected a fine plant here, equipped with the latest improved American machinery, and is now employing a large force under experienced American engineers. The general manager is Mr. A. Kapteyn, of London, who is assisted by Mr. Walter Philips, of Philadelphia, and by American experts in charge of the various departments.

This order involves the equipment of 300,000 cars, as well as a large number of locomotives, 60,000 of which are to be fitted with Westinghouse air brakes and 240,000 with air pipes and couplings inside of three years. This will place all the cars under control of the air brake, an improvement over the American system of making up trains of freight cars with and without air brakes, making it impossible to control the cars without the same.

Russia is the first country in Europe to use the continuous air brake for its freight and military trains.

While Russia began the development of its industrial resources much later than other nations, she is pursuing the policy of equipping her new factories with the latest modern machinery and adopting the most perfect methods of manufacture, as shown in the many new industrial plants in course of construction, which are almost without exception among the finest to be found in Europe. These are being assisted by the enterprise of Americans, who are beginning to appreciate and take advantage of the opportunities offered by this country.

The most important articles of the order are given below:

[Translation.]

ON THE INTRODUCTION OF CONTINUOUS AUTOMATIC BRAKES IN FREIGHT TRAINS OF RUSSIAN DIRECT COMMUNICATION RAILWAYS WITH NORMAL 5-FOOT GAGE.

MINISTRY OF WAYS OF COMMUNICATION,
June 19, 1899.

ART. 1. In virtue of the opinion of the State Council, recorded on March 30, 1898, imperially sanctioned, continuous automatic brakes are to be applied to the engine and trucks of the freight stock circulating in direct traffic on the Russian system of normal 5-foot gage railways.

ART. 2. In conformity with the decision of the Ministry of the Ways of Communication and of the extraordinary congress of representatives of the service of rolling stock and traction, summoned in January of this year (1899), on the question of the choice of the fundamental system of continuous automatic brakes for freight trains, the Westinghouse system of brakes is adopted.

ART. 3. The introduction of other systems of continuous automatic brakes is allowed upon condition: (*a*) Of the previous trial of the new system on trains of local circulation, during not less than three years, for its thorough trial under the ordinary conditions of working; (*b*) of the possibility of the combined action of the new system with Westinghouse's system; (*c*) of the mutual interchangeability of the connections (couplings); (*d*) previous to the introduction of the new system into direct communication, the question of its practical suitability for this object is to be considered by the Congress of representatives of the service of rolling stock and traction, and the ratification of the conclusion of this congress is to follow the usual course.

ART. 4. The equipment of the freight stock with continuous brakes is to be carried out in the following sequence:

(*a*) In the course of the first four years, brake apparatus will be placed on all freight engines and tenders.

(*b*) In the course of the same period of time, main pipes will be placed on all freight trucks in direct traffic.

(*c*) In the course of the same four years, the wagons which have to be provided with continuous brakes will be equipped with foundation brakes, and the equipment of these wagons will be made complete, maintaining the hand brake, but the brake apparatus of the wagons must be taken down and kept in stock until the time when it will be fixed permanently to the stock.

(*d*) With a view to carrying into effect points *a*, *b*, and *c*, there will be ordered in the course of the first four years the necessary number of engine and carriage fittings, connecting tubes, and brake gear.

ART. 5. During the second period of time—i. e., after the expiration of the first four years—all the brake trucks in direct traffic will be supplied with brake apparatus and guards' taps and all the carriages of direct communication (both braked and nonbraked) with rubber hose couplings, two to each carriage. The rubber hose couplings must be got ready in due time.

ART. 6. In the course of the second period of time, premises will be constructed for the storage of spare parts necessary for the maintenance and repair of the brake fittings, and the necessary number of spare parts provided.

ART. 7. On freight engines, first of all, the tenders will be equipped with brake apparatus.

ART. 8. Brake blocks will be applied to the driving wheels of the normal freight engines after the necessary alterations in the construction of these engines have been made. The fitting of brake blocks to the driving wheels of freight engines of other types is left to the discretion of the local managements of the lines, depending on the construction of the engines.

ART. 9. The work indicated in article 8 will be proceeded with not earlier than after the complete termination of the work indicated for the second period.

ART. 10. The periods of time for the work indicated are: First period, from January 1, 1899, to January 1, 1903; second period, from January 1, 1903, to January 1, 1905; third period, from January 1, 1905, to a date not predetermined.

ART. 11. When fixing the main brake pipe to the carriages, before the complete equipment of the brakes can be finished and until a decision has been taken as to the most rational means of preserving the connecting tubes from chocking and rusting, these tubes will be stopped with solid wooden stoppers, and these stoppers cut flush with the edges of the tubes, so that they cannot be taken out.

Remark.—It is allowed to bring forward, for the consideration of the next consultive congress of the representatives of the service of rolling stock and traction, the question of the application of some other more expedient means of preserving the connecting tubes from choking, until the time that the brakes are brought into use.

ART. 12. For the brake blocks of the engines, tenders and carriages, the type of blocks of the normal goods truck will be adopted.

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ART. 14. After communicating with the managements of the various lines, the number of braked vehicles of the non-normal type which it will be expedient to equip with air-brake apparatus will be indicated; and in conformity with these indications and the number of normal brake carriages available on State and private lines, the building of new standard vehicles with brake will be arranged for, and the necessary credit asked for the State railways, and the necessary means found for the private railways, so calculated that by January 1, 1903, there shall be on the various lines the whole number of braked vehicles required, as prescribed in article 24 of the present order.

ART. 15. For acquainting the staff of servants with the construction of the brake appliances of the Westinghouse system, and for the instruction of that staff in the operation and regular use of the brake, there will be used training or instruction carriages provided with drawings, models, and installations containing all the parts of the brake system and capable of being brought into action in the same manner as is done on the train.

Negotiations will be entered into with the Westinghouse Company for the preparation, for the State railways, of one such carriage, in order that, in the course of the first period, a tour may be made over the State lines in the said carriage by skilled persons from the said firm, for imparting to the staff of servants the necessary instructions.

The question of the introduction of such instruction on private lines is left to the discretion of the managements of these lines.

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ART. 19. Of the various systems of brakes tried by the brake commission, one superior system (not reckoning the Westinghouse system), admitting of harmonious action with the Westinghouse system, is to be introduced on the passenger trains of one of the railways indicated by the direction of the Ministry of the Ways of Communication, with the proviso that the brake system selected is to be subjected on the said line to trial and through the test under the ordinary conditions of working, during a period of three years, after which the question of the expediency of adopting this system for the goods carriage stock will be considered.

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ART. 24. The number of freight cars in direct traffic to be equipped with complete brake apparatus must be in accordance with the rules now in force for hand brakes (20 per cent.).

ART. 25. The equipping of the freight stock of the Trans-Caucasian Railway with continuous automatic brakes is to be carried out independently of the present rules, viz., the engines, tenders, and vehicles, of this road to be provided simultaneously with complete Westinghouse brake apparatus, pressure-retaining valves, brake-gear connecting tubes, intercarriage hose couplings, and guards' taps.

The number of braked axles to be established in accordance with the profits of the road.

The brake-block pressure to be established in accordance with article 13 of the present order.

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ART. 29. Private railways are allowed to order brake apparatus of the Westinghouse system, according to their discretion, in whole sets or in separate parts and to give these orders either through the management of the State railways or by independent contract, as may be found of most advantage to them.

The draughts of independent contracts concluded by the managements of private railways for the supply of the above-mentioned brake apparatus must be presented for approval to the Ministry of Ways of Communication, with a detailed explanation of the reasons on account of which the management of the road prefers ordering by independent contract and not through the intermediary of the State railways department.

At the same time, the managements are forewarned that they can reckon on the approval of the ministry of the said draught contracts, only in case there should be incontestable advantages in doing so as compared with ordering the same articles through the intermediary of the State railways department.

ART. 30. There will be communicated to the managements of private railway companies, for their information, a copy of the contract concluded by the State railways department with the Westinghouse Company.

American Steam Plows in Hawaii.—Several days ago, there was landed at this port, for the American Sugar Company, a set of steam plows made by an American firm. These plows, I am told, says Consul-General William Haywood, of Honolulu, are the first of the kind made by an American firm, those heretofore made in the United States not being of the cable description, but worked by the engine hauling the plows over the land. These new plows were made by the O. S. Kelley Company, of Springfield, Ohio. They were ordered through their local representative, Mr. William C. Gregg, who, I am told, intends to remain here and see that no more orders go to Scotland.

Heretofore, all the steam plows used in Hawaii came from Scotland, because they were cheaper, and also because American manufacturers did not make the kind employed here.

The O. S. Kelley Company agreed to furnish the plows as cheaply as the Scotch firm would, and guaranteed that they would be the equal in every particular of those now in use. The company wisely sent its own men over to set them up.

The plows cost $20,000 per set, and were delivered in forty days less time than if ordered from Scotland.

It is estimated that during the next three years, some twenty or thirty sets of plows will be required for the new plantations. They will all be bought in the United States, if the ones just received prove equal to those made in Scotland.

The American Sugar Company owns one of the new plantations and has justified its name by being the first sugar estate on these islands to use steam plows of American make.

Shipments to Chile.—The French Chamber of Commerce of Santiago de Chile has recently forwarded a communication to the chambers of commerce of France, which I translate below (says United States Consul J. C. Covert, of Lyons, France), as it will be of equal importance to Americans who have business relations with that country.

At present, the majority of French houses doing business with Chile insert the names of the real purchasers or consignees on the bills of lading. However natural this may seem it is none the less dangerous.

It may happen that between the departure of the order and the arrival [of the goods] in Chile, the situation of the purchaser has materially changed. Then the bank or the agent charged to remit the documents, who may wish to prevent the delivery of the goods, is placed in an embarrassing situation, because the documents being in the name of the consignee or purchaser, either he, or his assignee, if he has failed, has the right to seize the goods in the customs house. If the bankrupt or his representative does not claim the goods, the customs officers will hold them, and the seller, to obtain possession of his property, must bring a suit for annulment of contract, which is far from easy and may readily become onerous.

To obviate all this, it is only necessary for the shipper to observe the following suggestions:

(1) If the bills of lading are remitted to the purchaser or consignee in exchange for the acceptance of a draft, the best plan is to draw them to the order of a bank, which indorses and changes them for the accepted drafts.

(2) If the immediate acceptance of the draft is not demanded, an understanding may be had with a bank by addressing the bill of lading to it and making use of its intermediary. That will cost a slight commission, but it is cheaper than to lose the goods.

If the bills of lading are to be remitted by an agent to the purchaser or consignee, it is wiser to send them at once to the agent.

In following these suggestions, shippers will avoid a great many unpleasant surprises and difficulties, as nothing will defeat, in case of bankruptcy, their possible rights to the goods shipped.

Trusts in Germany.—Consul Brundage, of Aix la Chapelle, in an undated report (received by the department August 19, 1899), says:

As trusts are now being discussed in the United States, it may be of interest to know that practically every industry in my consular district is managed in this way. The report of the chamber of commerce of this city, just issued, urges the formation of a trust in the pin industry. The manufacture of pins has heretofore been accomplished by hand labor; but in view of the competition of American machinery, a combination of manufacturers, with the object of keeping up prices, is advised.

Last week, the owner of one of the oldest woolen-cloth factories in Aix la Chapelle, thoroughly conversant with the trade of every country, said, when I asked him why he did not erect a factory in the United States:

"We can make more money by manufacturing here. Your labor is too high, and your woolen cloth men do not stand together; they cut prices too much. Here, we regulate our business, and can adapt ourselves to competition by controlling prices and labor. We made a great deal of money before the high tariff went into effect in the United States."

Tobacco in Spain.—Consular Agent Mertens, of Grao, under date of August 18, 1899, says:

In my report of February 15, 1899, I drew attention to the demand for American tobacco by the Spanish tobacco monopoly. Since then, there has been a purchase of 5,000,000 kilogrammes (11,023,000 pounds) of Kentucky tobacco from a Paris syndicate. This will be delivered by December, when another purchase has to be made. American tobacco dealers ought to be able to offer directly to better advantage.

Antwerp-San Francisco Steamship Service.—Consul-General Lincoln, of Antwerp, on August 30, 1899, reports that according to the Matin, the leading morning journal of that city, the German steamship company Kosmos has decided to establish a monthly steamship communication between the ports of Antwerp and San Francisco direct, touching at Pacific ports.

The steamer destined to inaugurate this new service, the "Tanis," will leave Antwerp on September 23, next.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

No. 543. October 2.—Mining and Agriculture in the Yukon Territory—The German Beet Sugar Campaign of 1898-99—*Pumps in Cape Colony—*Inspection of Forestry in Canada.

No. 544. October 4.—*New Use for American Dried Apples in France—*British-German Trade—*Emeralds in Colombia—*American Wheat for the Manufacture of Macaroni—*United States vs. German Trade in Argentina—*German-Guatemalan Trade Mark Convention.

No. 545. October 5.—Regulations Relating to Foreigners in Japan.

No. 546. October 6.—Regulations for New Ports in Japan—*Japanese Market for Wood Pulp—Government Advertising in France—*Congress of Medicine in Paris—*Belgian Enterprise in Egypt—Tolls in Belgium.

No. 547. October 7.—British Shipping Trust—*American Trade Competition with Great Britain—*Excessive Freight Charges to Great Britain—Greek Quarantine Regulations.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

[Continued from Supplement, No. 1241, page 19869.]

BOATS AND SAILS.—II.

By Walter Burnham.

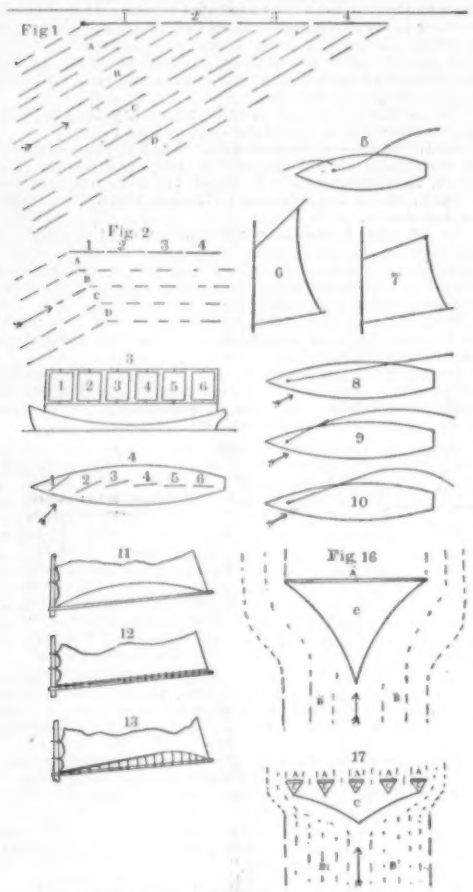
SAILS.

Supposing four playing cards be stood vertically in a row, with their edges touching, and the area thus made be regarded as a sail, as represented in Fig. 1. The wind which would pass through a line equivalent to the right hand edge of the fourth card and the left hand edge of the first card (that is the after-leech of a sail and the mast) may be regarded as a column of wind divided into four parts, *A*, *B*, *C*, *D*, moving in the direction shown by the arrow.

In Fig. 2, *A* is the column of air which strikes on the first card and is turned or deflected by the first card and passes aft over the three remaining cards. This column of wind does not lose its dimensions very much. A little is "spilled" over the top and bottom of the card but it turns in bulk. If it does not turn in bulk, that is to say, if the bulk of wind is materially affected, then its pressure must be materially increased or diminished, which is seen at once not to be the case, or the wind must be backed up.

For many years I was under the impression and conducted my experiments under the belief that the wind did materially lessen in its bulk, but of late years I have become positive in the opinion that the deflection of wind which would have struck on the first card, or the section of the sail nearest the mast, remained about the same in size, density and velocity and passed aft over the sail. This is why I speak so positively.

Column of wind, *B*, is that column which would strike on card 2, but which never reaches the card because the deflected wind, *A*, from the first card is interposed between it and the sail. Similarly so in *C* and *D*. It will then be seen that on the first part of the sail there is a very good wind; on the second part of the sail a mixture between a dead-ahead wind and a favorable wind; on the third part of the sail two dead-ahead currents; on the fourth part, three.



ACTION OF WIND ON SAILS.

In investigating this further, the following experiment was tried, shown by Figs. 3 and 4. On a boat a framework was put up that carried six smaller frames, covered with muslin, thus constituting sails. Each of these six sails was pivoted in the center so that they might take any angle. The first plate or sail was set at the angle shown by No. 1, Fig. 4, the course of the wind being shown by the arrow. No. 1 was fastened in this position. Then No. 2 was slowly moved until it was found to be set at the angle which received some wind, that is, "set so it would draw" and fastened. Nos. 3, 4, 5, and 6 were similarly and subsequently so set. When it was found that No. 5 was set almost fore and aft, the leech or after part of sail No. 6 was really to windward of the keel. This may seem, when so stated, astonishing, but it will readily be conceded when it is remembered how the jib will "back" the mainsail as shown in Fig. 5, or how much more inboard the boom of a mainsail must be drawn than that of the foresail, and numbers of other similar experiences.

Attention is also called to the fact that if some cotton be thoroughly saturated with tar and lighted, the smoke from it cannot be made to touch the sail unless held forward of the mast and quite in line with the wind. As you go to windward of the mast the distance the smoke will remain from the sail increases, going to show that the bulk of the wind as it is turned by the sail does not materially diminish.

For these reasons, attention is called to Figs. 6 and 7. Fig. 6 representing a tall and narrow sail, which is undoubtedly the speediest; Fig. 7 being a low and broad sail, which is undoubtedly the slowest.

The course of the deflected wind and its unaltered bulk, is without doubt the explanation of why a catboat can outpoint a sloop, and a sloop outpoint a schooner, and a schooner outpoint a ship.

Fig. 2 and the facts that are gathered from it, are also an explanation of why a perfectly flat sail, as shown in Fig. 8, is not good. It also shows why a bellied sail is better than a quite flat sail, as shown in Fig. 9, and it would also point to the proper curve in a sail being that shown in Fig. 10. In old times they used to fasten the sail free on the boom, as shown in Fig. 11, which represents a too much bellied sail for beating. The custom now is to lace the sail on the boom, as shown

Fig. 1.

in Fig. 12, and I think that with the lacing of the sail it is very easy to secure a too flat sail, as shown in Fig. 8.

I have almost always been able to speed a boat up and increase her windward work materially by relacing it on the boom, as shown in Fig. 13.

Figs. 3 and 4 suggest an experiment in sails which I have very thoroughly tried, and of which illustrations are given later, but before I leave the sketches I wish to explain what I have found to be the case in a sail running before the wind, as illustrated by sketches 16 and 17.

In Fig. 16, *A* is the sail and *B B* is the wind, and *C* is the cone of dead air that rests upon the sail. Allow me to liken the sail and the wind and this cone of dead air to one's putting his hand into sand and moving it. It would be found that a cone of sand remains on the hand. Any one who has gone out on the boom of a sail "running" has found himself in a place of comparative calm, the smoke from his cigar remaining with him. If the sides of the cone are at a correct angle, the wind will be "split" and pass the sail without exerting its greatest effect on the sail, whereas if the sail have openings in it they allow the base of the cone to constantly pass through, bringing the apex nearer the base and increasing the angle of the cone. In a sail of 100 square feet area, I have found that 65 per cent. of the area being covered by cloth and 35 per cent. of the area being open, their speed was equal. What I have said of Figs. 16 and 17 must be thought of when looking at the following photographs.

PHOTOGRAPHS OF SAILS.

The accompanying photographs are a few of many

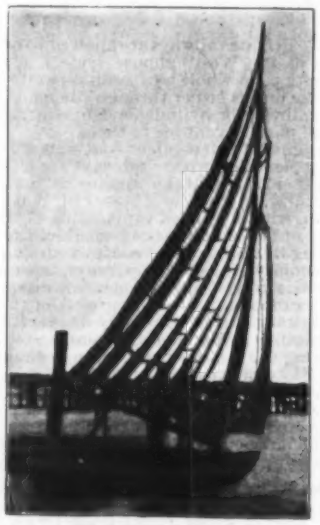


Fig. 2.

experiments that have been tried—the general results may be stated as follows:

In running before the wind, all sails set at right angles to the wind are materially benefited by having holes in them through which the wind may escape and thereby lessen the height of the cone of dead air that rests on the sail. In beating, the sails are subject to a very much greater windage than they would be if there were no openings in them. Each section may be considered a little sail on the hoist of which the windage is felt. When a large sail is composed of a number of small sails, the "windage" of the large sail is very materially increased, as has been explained above, and this "windage" or direct contact of a substantially dead-ahead wind is so material that unless the advantage gained by getting rid of the "spilled" wind is very great the "windage" is materially felt, the result being that while any one of the forms that I have tried causes the boat to move at least one-half faster on a certain wind (that is on wind particularly adapted to the slant of the members and their "spill") on any but that certain wind it is a trifle slower than an ordinary sail.

Taking the whole field and sails as they are used, the old form of sail, that is, the sail having no openings in it, is best.

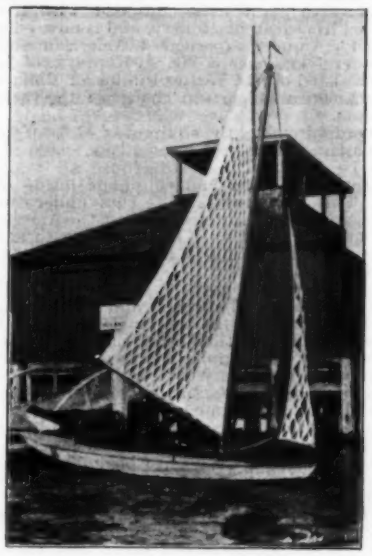


Fig. 3.

I present the accompanying photographs, as they may be of interest as photographs of odd forms of sails, and further in the belief that some of the phenomena shown in them may be of material benefit in setting sails and also in cutting them.

The accompanying photographs are not arranged in order, but being numbered, attention can be called to each one.

No. 1. This is a sail composed of strips running perpendicularly. Each strip is kept flat and stretched apart by strips of wood inserted in pockets, that is, "stretchers" are used, or "battens," the last or stern cloth is the sail having five battens in it. These strips were connected together by being tied at the points where the battens came, the front edge being held taut, the rear edge of the one in front of it strung out to leeward the distance which the uniting string allowed. By tying them close in or far out I could learn the thickness of the "spill." These experiments soon proved that the "spill" was about as thick as the current of direct air which struck on each strip. No. 2 is a view from the rear, which shows the opening between the strips through which the "spill" passed. (It is assumed that the wind deflected by one member passes off of that member to leeward, and on in front of the next member behind it.) No. 3 is a different form. In this, each member is in the form of a triangle, its apex forward.

In No. 4 the strips run horizontally and they are connected together by net work. This sail showed the advantage of all of them in running, and was a little slow or dead in beating.

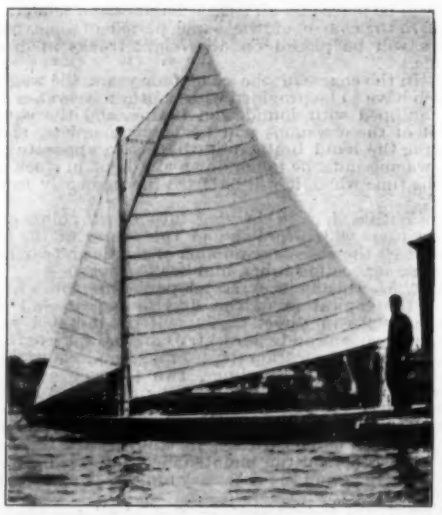


Fig. 4.

In No. 5 the arrangement of the strips is different on the leech, the strips being parallel with the mast instead of being parallel with the leech as in forms 1 and 2.

No. 6 is that photograph of those shown from which the greatest information may be derived. It is made of individual perpendicular strips which one raised and lowered by an individual halyard and downhaul. In this way I could set the first three and leave unfurled the next two, and set the next one-half way up, the next one three-quarters, and the next one-quarter, but

in that way getting exact balance. The members being individual and all set, when I gave it a good full of wind, "laid down" in their proper order. As I gradually let out the boom, one member after another would spring to windward and belly out just as much to windward as the other members did to leeward. As I caught this snap shot, it will be seen that while members 1, 4, 5, 7, and 9 remain bellied out to leeward as they should be, that members, 3, 6 and 8 are similarly bellied out, but to windward. I account for this by the thickness of the current of deflected wind. No. 7 shows the same sail full of wind.

No. 8 is a view of the same sail shown as in Nos. 1 and

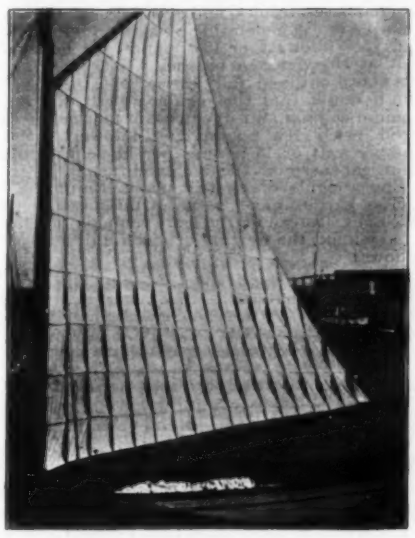


FIG. 5.

2, in which strips Nos. 2 and 8 are furled and Nos. 3 and 7 are half hoisted.

No. 9 represents two boats with substantially the same kind of sails, the difference being that the forward sail is composed of five members, whereas the rear sail is composed of six.

For a long time I have been convinced that the more individual members in a sail, the speedier it was. (I have asserted above that these sails are very much more speedy when sailed as they are adapted to be sailed, that is, on a certain wind and course only.) These two sails then are exactly of the same dimensions, placed on boats of the same model and sailed the same course, all things being alike but the sub-divisions of the sail, in one case into five members, in the other case into six. I always started the sail with five members ahead of the sail with six members, and invariably the sail with six members out-sailed that with five. (I have often wondered in view of the above experiments on the hull and sails, if the fastest boat under certain conditions would not be a boat of immense boom and shallow draught, that had a number of sails set on masts, that ran across the boat instead of fore and aft.)

Nos. 10 and 11 represent the same sail under different conditions.

In No. 10 particular attention is called to the belly in the sail. This belly of the front member caused me to think that the sail would be improved by its removal.

In No. 11 the first and second members are wrapped around the mast, and I assert it to be the fact that in certain winds the sail in the condition shown in No. 10

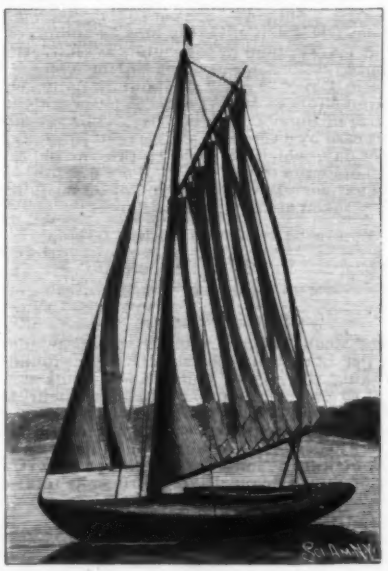


FIG. 6.

was faster than that shown in No. 9, going to show that the forward part of most sails simply "splits" the wind; that it can be given the slight deflection without meeting with much impetus and without causing much increase of pressure upon the windward side and decrease of pressure upon the leeward side. This experiment goes far toward confirming the opinion previously expressed, that the curve of a sail should be from the mast aft a gradually increasing one.

I feel that the hull of boats is better understood and carried out than is the set and draw of the sails. I suggest that when, as has often been the case, two boats of seemingly the same model of hulls raced, the different results were more attributable to the sails than to the hulls.

CANAL BOATS, STEAMSHIPS, SAILING VESSELS.

It will be seen that the force that pushes these several kinds of boats onward is applied in different manners—the canal boat tow line forward, the steamship

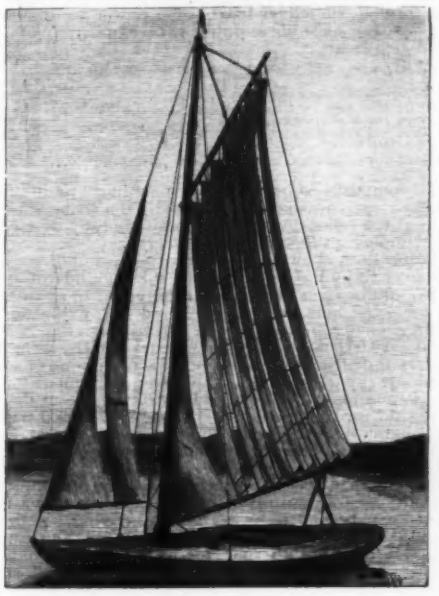


FIG. 7.

screw aft, and the sailing boat's sails aloft and sideways.

In deciding upon the correct model for the hull of a sailing vessel, the otherwise unusual problems of resistance, the side force of the wind on the sails which tends to tip over the boat, must be considered.

This side force of the wind on the sails may be coun-

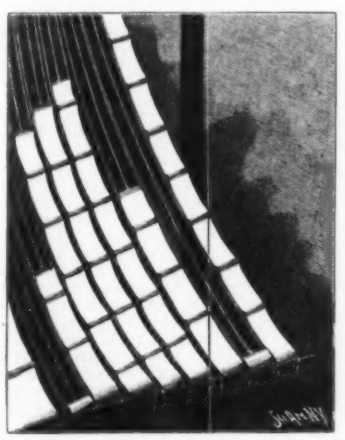


FIG. 8.

teracted in two ways. One is to make the boat of great draught and heavy keel; the other is to make the boat of little draught, great beam, and not very heavy. Each form has certain advantages and disadvantages when all conditions of wind and water are to be met with.

To find that model which has the fewest disadvan-

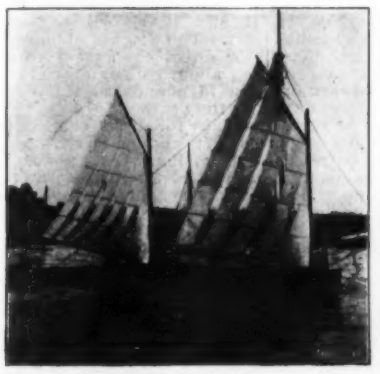


FIG. 9.

tages and the greatest advantages when all conditions of wind and water are to be met and to supply such model with sails which will secure the greatest advantage from the wind with the least side impulse makes the model and rigging of sailing vessels a far more interesting problem than that of canal boats and steamships.

I feel that in the facts here shown may be found many truths (and, of course, there are probably many fallacies and wrong deductions), and I take pleasure in making them public that others may carry the matter further.

The sketches and photographs here given do not show all my experiments by any means. I have innumerable photographs of sails, and I carried out various other ideas in models.

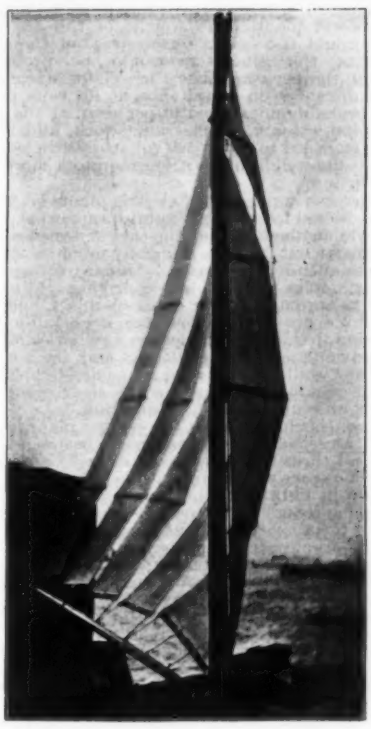


FIG. 10.

What I have said above simply touches on certain of the principles. If any one desires, I will gladly show and tell him all that I have done and the deductions I draw from it.

ELECTRIC AUXILIARY MACHINERY IN THE UNITED STATES NAVY.

By ALTON D. ADAMS.

SINCE the tests on board the "Minneapolis" by Mr. W. W. White, which showed that her steam auxiliaries consumed 119 pounds of water per horse power hour on the average, especial attention has been turned to the subject of electric driving. The plan for electric driving is, briefly, to substitute for each small auxiliary steam engine an electric motor of equal capacity, and to install enough electric generators, direct connected to compound engines, for the maximum demand of these motors at any one time. Efficiency is the great advantage that has been claimed for the electric equip-

FIG. 11.

ment, as it is readily shown that compound engines, electric generators, and motors require only about one-third the weight of steam per hour demanded by the small engines now in use for the same work. This decided gain in efficiency is quite generally admitted, but the various arguments for and against the proposed change have been in some cases amusing rather than instructive.

For instance, one writer has said, "At the same time it is impracticable to install on board ship dynamos of

more than 1,000 amperes, so that thirteen dynamos would be required to give the necessary power at 80 volts," but has not explained the mysterious reasons which would prevent dynamos giving 5,000 or 10,000 amperes working to that entire satisfaction on warships which they commonly give on shore.

Again, another recent writer has said: "Such a voltage (80 or 100) is, however, entirely unsuited for a 1,000 horse power plant. The weight of the distribution system would not only be excessive, but the size and weight of the generators would be prohibitive," although the facts are that the weight of conductors for the distances on board ship, at 100 volts pressure, would probably not exceed 10 per cent. of the present steam-pipe weights for the same work, and that the change from 100 to 250 or 500 volts pressure would not decrease the weight of electric generators more than 5 per cent.

An increase in pressure of electric plants on warships is to be desired in order to diminish somewhat the cost of electric conductors, and the care of brushes and accumulators; but this is a decidedly minor matter, and failure to abandon the present standard voltage should not be stated as fatal to electric driving. Conclusions as well as arguments differ on this subject, one having said: "We are driven, therefore, irresistably to the conclusion that, although electric auxiliaries offer very many advantages, their great cost and the amount of space they would occupy render a complete installation of them of doubtful benefit, while their great weight makes it absolutely out of the question."

Another concludes that "The electric plant, with the generating sets described, will weigh between two and a half and three times the steam drive," but later says that "The space required for 200 to 400 tons of coal is available in addition to that space at present allotted for dynamo room." The writer is unable to agree with either of the above views, first, because the total weight of machinery necessary for electric driving is less than that required with steam alone; and secondly, because it seems improbable that, with the pressing demand for greater steaming radius, any coal space will be given up to machinery, even though the coal consumed by auxiliaries is reduced. If the relative weights of equipment for steam and electric driving are necessary as above stated, it may well be feared that the introduction of the electric motors and dynamos for the work is to be a slow and uncertain change, but it can easily be shown that such is not the case. The solution of this entire question, the proven efficiency and reliability of electric driving being granted, depends directly on the test of weight for the electric and steam equipment, and by this test the future applications of one or the other must be largely decided.

The weights usually quoted in matter on the subject of electric driving are for engines and dynamos of about the same construction as is common in those machines for use on land, in which cast iron is largely used, a metal having less than one-half the value of wrought iron and steel in strength and magnetic properties. The extended use of cast iron in the main engines and other machinery of warships ceased to be good practice some years since, and there is no good reason why driving engines for dynamos and electric motors should not be constructed with special view to light weight for use on shipboard. The great weight of electric equipment and its driving engines on board warships is probably due to the fact that while the main engines and machinery in war vessels are usually built on plans of the government engineers, or under their rigid specifications as to materials and weights, the electric equipment has been substantially the same as that in common use on land as to materials and construction. It is true that the navy regulations limit the weight of engines and connected dynamos complete to one-third of a pound per watt of output, or 746÷3=248·6 pounds per horse power output; but this specification amounts to but little, as manufacturers can ill afford to make generating sets heavier than this, since even cast iron is costly in large quantities. When upward of $500 per ton is paid for armor plate, main engine shafts are forged hollow, and all the general machinery in warships is designed for the required strength with minimum weight, there seems no good reason why electric equipment should not be required of the smallest weight consistent with the best results, without regard to any slight increase in cost. The truth, perhaps, is that electrical machinery being of comparative recent use in the navy, has not received that attention from government engineers that has been given to other branches. The efficiency of electric equipment for driving auxiliaries on warships has been placed at higher figures, but the writer believes the following to be as good results as could regularly be attained in practice.

Combined compound engines and dynamos may be expected to have an efficiency of about 80 per cent. if worked at nearly full load, and electric motors and conductors also 80 per cent. under at least three-fourths full load. Above efficiencies give for the ratio of power delivered by motors to the indicated horse power of engines, as 0·8 × 0·8 = 0·64, or 64 per cent.

Any good compound engines should develop indicated horse power at the rate of 1 horse power on 20 pounds of steam per hour, and an allowance of 25 pounds steam per horse power hour, in consideration of some underloading and other losses, is liberal. At an average of 25 pounds of steam per indicated horse power hour, and a combined efficiency of 64 per cent., the steam consumed per horse power hour delivered by the electric motors is found by 25 ÷ 0·64 = 39 pounds, or only 39 ÷ 119 = 0·328, or about 33 per cent. of the steam required for steam using auxiliaries in the "Minneapolis" test. Stated in another way, the electric equipment would save 119 — 39 = 80 pounds of water per horse power hour delivered at the motors. Taking the capacity of auxiliary equipment in a battleship at 2,400 brake horse power, it may be safely assumed that not more than one-half this auxiliary capacity will be in use at any one time, or 1,200 horse power delivered. With line and motor combined efficiency at 80 per cent., the power required from dynamos will be 1,200 ÷ 0·80 = 1,500 horse power, and that from engines 1,500 ÷ 0·80 = 1,875 horse power, combined engine and dynamos efficiency being 80 per cent.

At the government limit of 248·6 pounds per horse power output from dynamos of generating sets, the weight of engines and dynamos to deliver the 1,500 horse power will be 248·6 × 1,500 = 372,900 pounds. The weight of medium-speed motors, as commonly made, may be taken at 100 pounds per brake horse power output, so that the total weight of the 2,400 horse power for auxiliaries will be 2,400 × 100 = 240,000 pounds.

The weight of steam engines driving auxiliaries in warships will probably average 125 pounds per brake horse power, and in many cases they exceed this figure. The weight of 2,400 horse power engine capacity at 125 pounds per horse power is 2,400 × 125 = 300,000 pounds for the steam drive.

Summing up above weights, the following results for a ship plant to deliver 1,200 horse power to auxiliaries aggregating 2,400 horse power total capacity:

	Pounds.
Total weight engines and dynamos to deliver 1,500 horse power	372,900
Total weight electric motors	240,000
Total weight of electric equipment	612,900
Total weight steam drive for 2,400 horse power	300,000
Excess of electric equipment over steam engines	312,900

All comparisons between the machinery required by the two systems that have come to the writer's notice stop at the point just reached, and thereby overlook a very important factor in total weight.

It has been shown above that the saving of the electric over the purely steam drive is 80 pounds of steam per hour for each horse power delivered to auxiliaries, so for 1,200 horse power delivered to auxiliaries the hourly saving in steam with electric driving is 80 × 1,200 = 96,000 pounds. A low figure for the weight of boilers and attachments is 5 pounds per pound of steam per hour capacity, so that the boiler equipment for the 96,000 pounds steam required by direct steam driving over that for the electric is 96,000 × 5 = 480,000 pounds additional. As the total boiler capacity necessary for the main engines must be had at the same time the total boiler capacity for the auxiliaries is wanted, the total boilers in the ship must be the sum of these two and the 480,000 pounds in boiler capacity above mentioned can be omitted with electric driving. A proper amount of feed water must be carried for the main engines in addition to that for auxiliaries, so that the 96,000 pounds of feed water required by direct steam driving over the electrical per hour may also be omitted from the ship, since water would not be returned to boilers more than once per hour. Taking these weights of boiler plant and feed water saved by the electric system in connection with the figures above found gives the following.

	Pounds.
Weight of steam driving of 2,400 horse power capacity	300,000
Extra weight of boilers required	480,000
Extra weight of feed water required	96,000
Total for steam driving not required in electric	876,000
Total for electric driving	612,900
Saving in weight by electric driving	263,100

From this it is evident that electric driving, instead of being so heavy, compared with direct steam as to forbid its introduction, actually effects a saving in weight equal to a large part of that of engines in direct steam driving. But the comparison is not yet complete, since the weights stated above for the electric system are based on those common in land plants, and it is by no means necessary or desirable to use such heavy machines on board ship as the present navy regulations allow. It is interesting to note in some detail by what constructions the weights of driving engines, dynamos, and motors may be reduced. Compound engines, as now offered by most makers, weigh from 100 pounds to 150 pounds per indicated horse power complete, including the extended bases to receive dynamos. Frames, bases, and cylinders of these engines are mostly of cast iron, while crank shafts, connecting rods, and piston rods are of solid forged steel or steel castings. The improved construction desirable for light weight involves the substitution of steel castings for cast iron in bases and cylinders on account of its greater strength, hollow-forged steel frames in place of cast iron, and hollow-forged steel crank shafts, connecting rods, and piston rods for the solid steel forgings and castings now used for these purposes. The lighter construction of connecting rods, piston and piston rods, makes the high rotative speed so desirable for dynamos more easily attainable. The net result of such improvements on compound engines is to reduce their complete weight, with extended bases for dynamos, to 60 pounds or less per indicated horse power.

A few engine builders have made use of this improved construction for light weight, and with their general requirement for marine work there is no reason why this method of building should not become common. A good illustration of several of the features of construction is found in the drawings for new W. S. battleships Nos. 10, 11 and 12, shown in Commodore Melville's recent report. The weights of most electric generators offered for direct connection varies with different makers from about 100 pounds to 150 pounds per kilowatt, or from 75 pounds to 112 pounds per horse power output at the brushes.

Many of these dynamos for direct connection have cast iron armature spiders and magnet frames, which should be replaced in an improved construction for light weight by steel castings or wrought iron forgings. The proportions of many dynamos offered for marine work should also be so changed as to shorten magnet cores and increase somewhat the per cent. of copper compared with iron, as in this way the total weight of many dynamos can well be reduced. With the improvements above indicated the total weight for direct connected marine generators may be readily reduced to not more than 75 pounds per kilowatt, or 57 pounds per horse power output at the brushes. Seventy-five pounds per kilowatt output by no means marks the ultimate of improvements in the matter of weight, but is an actuality of material already attained by some large makers in their regular machines. Improvements to reduce the weight of small and medium-sized motors, as in the case of large dynamos, is to be attained by the substitution of steel castings and wrought iron forgings for cast iron, and in this way a weight of not more than 75 pounds per brake horse power capacity can easily be attained, and has, in fact, been surpassed in a number of cases.

With an efficiency as above of 80 per cent. for the engine and electric generator combined, for each horse power of electric energy delivered at the brushes the engine must develop 1 ÷ 0·8 = 1·25 indicated horse power. The weight of engine per horse power delivered at the dynamo brushes will therefore be from the above 1·25 × 60 = 75 pounds, and with the weight of dynamos at 57 pounds per delivered horse power, the complete weight of generating set is 75 + 57 = 132 pounds per horse power of electric energy, or 132 ÷ 746 = 0·17 pound per watt output at brushes, instead of 0·33 pound per watt, or 248·6 pounds weight per horse power output at dynamos as allowed by the navy limit. That these reduced weights are not too low is shown by the fact that they are slightly bettered at this time by makers who have adopted the improved constructions above indicated in some sizes, while at least one large manufacturer who still uses cast iron for engine bases, frames, and cylinders, offers regularly for marine work generating sets weighing about 100 pounds per kilowatt, or 120 pounds per horse power output at the dynamo brushes. With the improvements above outlined fully carried out, there seems no reason to doubt that the regular weight of combined compound engines and dynamos for marine use can be reduced below 100 pounds per kilowatt, one-tenth pound per watt or 75 pounds per horse power output of electrical energy at the dynamo brushes.

Basing weights of electric plant equipment for a first-class battleship on actual attainments, as above pointed out, instead of the more common practice and the navy limit, the weights of electric driving will be as follows:

	Pounds.
Weight engines and dynamos to deliver 1,500 horse power equals 1,500 × 132 equals	198,000
Weight 2,400 horse power capacity electric motors equals 2,400 × 75 equals	180,000
Weight of driving engines, dynamos, and motors equals	378,000
Weight of 2,400 brake horse power steam engines equals 2,400 × 125 equals	300,000
Weight of extra boilers required as above found equals	480,000
Weight of extra feed water required as above equals	96,000
Steam driving equipment not required by electric equals	876,000
Electric driving equipment not required by steam equals	378,000
Saving in weight by the electric equipment equals	498,000

Instead, therefore, of the prohibitive weight, or one two and a half to three times that necessary for direct steam drive, electric driving actually saves a weight of total equipment greater than the total weight of small engines used for auxiliaries without electric equipment. It will be noted that above figures for the saving in weight do not include the difference in coal burned by steam and electric driving, though to be entirely fair to the electric system this should be considered, the reason for omitting the weight of saved coal being that it seems hardly probable that the amount of coal will be reduced, even though some is saved from auxiliaries, as there is great need of more for main engines than it is at present possible to carry, since much of the value of a battleship depends on the distance she can travel at a given speed without recoaling. There is, however, one particular in which the weight of coal saved by use of electric driving must be considered—namely, its cost, as this has a direct bearing on the possible saving with the electric equipment. The electric plant will perhaps cost more than the direct steam system, and it should be noted whether the saving in coal offers a suitable inducement for the increased investment.

One writer has said that "The first cost of the electric system would be about three times that of the steam system," and that "The electrical system could not be expected to pay for its increased first cost in less than five or six years of constant use." How accurate are these statements may appear from the following: The use of auxiliaries in ships is intermittent, but from the best data at hand an average use of one-fourth their total capacity for twenty-four hours daily seems a fair estimate. Direct steam-driven auxiliaries of 2,400 horse power capacity, on the basis of one-fifth average load during twenty-four hours per day, consume, at the rate found in the "Minneapolis" test, steam to the amount of (2,400 ÷ 5) × 24 × 119 = 1,370,880 pounds daily, which at 8 pounds of steam per pound of coal burned, requires 1,370,880 ÷ 8 = 171,360 pounds, or 171,360 ÷ 2,240 = 76·5 tons of coal daily.

For electric driving, taking only 39 pounds of steam per horse power hour at the motors as above, the steam consumed on the same assumption for average load is (2,400 ÷ 5) × 24 × 39 = 449,280 pounds daily, which as above, amounts to 449,280 ÷ 8 = 56,160 pounds, or 56,160 ÷ 2,240 = 25 tons of coal per day. The saving in coal for this case by electric driving is then 76·5 — 25·0 = 51·5 tons per day, which at so low a price as $6 per American ton amounts to the sum of 57·5 × 6 = $345. Cost of equipment for above electric plant on battleship may be fairly taken at the following figures:

Compound engines and dynamos to deliver 1,500 horse power at $50 equals	$75,000.00
Electric motors to deliver 2,400 horse power at $25 equals	60,000.00
Electric wiring and fittings for above equals	50,000.00
Total	$185,000.00

Direct steam driving requires 96,000 pounds more steam per hour than electric driving, as found above, and taking the cost of boilers and fittings at the low price of 50 cents per pound of steam per hour capacity, these additional boilers will cost 96,000 × 0·5 = $48,000, and the 2,400 horse power capacity of small steam engines at $20 per brake horse power will cost 2,400 × 20 = $48,000, making a charge of $10,000 for the extra steam piping of direct steam driving, brings its total cost up to $106,000.

The total charge for electric equipment equals	$185,000.00
The total charge for steam equipment equals	106,000.00
Additional cost of electric equipment equals	$79,000.00

Cost of fuel alone for the steam system was found above to be $345 per day more than that for the electric system, and this saving by the electric equipment amounts, therefore, to 345 × 365 = $125,925 per year, so that the extra cost of electric system can be paid for out of the coal saved in about 79,000 ÷ 125,925 = 0·62 year, or less than seven months. A just appreciation of the facts on which the above figures are based seems certain to result in the rapid adoption of electric driving for auxiliaries throughout the navies of the civilized world.

In spite of the great advantages as to weight and efficient operation inherent in the electric system for

warships, the navies of the United States and of the world are slow to avail themselves of it. So far as the writer is informed, the first complete electric driver of auxiliaries is yet to be installed on a first-class battleship, and in most cases the electric system is confined to a few of the less important auxiliaries. To illustrate how generally steam is still used to drive battleship auxiliaries, the following data concerning the United States seagoing battleship "Iowa" have been taken from the account of her contract trial by Passed Assistant Engineer J. M. Pickrell, United States Navy, and printed in the Journal of the American Society of Naval Engineers of August, 1897.

The "Iowa" was contracted for at a price of $3,010,000, her length on waterline is 360 feet, beam 72 feet 2·75 inches, and displacement corresponding to normal draught 11,340 tons. On trial trip the "Iowa's" main engines developed 11,834 horse power, and though the auxiliaries in use at that time developed only 236 horse power, there is good reason to think that the total horse power of auxiliary equipment is about 2,500. Aside from the main engines there are eighty-four auxiliaries in the "Iowa," with a total among them of 146 steam cylinders.

From the "Minneapolis" tests and the similarity of operation of auxiliaries on different warships, it is fair to assume that these 146 steam cylinders will consume about 119 pounds of steam per horse power hour, instead of the 25 pounds to 40 pounds per horse power hour that would be used in compound engines for the electric system. The electric plant of the "Iowa" includes four generating sets, each with capacity of 300 amperes at 80 volts, or 24 kilowatts, a total of but 96 kilowatts capacity for the four sets. Each generator is direct connected to a simple two-cylinder engine, each cylinder being 10¼ inches diameter and 5 inches stroke, running at 400 revolutions per minute, and using steam at 80 pounds pressure.

Each generating set complete—engine, bedplate, and dynamo—weighs about 8,500 pounds, or nearly 35 pounds per watt of output. These generating sets supply current for about 500 incandescent lamps, four search lamps, and the following electric motors: Two electric motors of 2 horse power each are used to drive fans that ventilate the dynamo room; four motors of ¼ horse power each are used to drive portable fans which exhaust air from various compartments; eight motors of 7 horse power each work the ammunition hoists in the 8-inch turrets; and seven other motors of about 5 horse power each are used on ammunition hoists in other parts of the ship.

The "Iowa," then, may well serve to illustrate the lack of electric plant and motor driving rather than what sound reasoning shows can and should be done in this direction. This high-grade seagoing battleship with modern armament, from her 12-inch guns down to those of rapid fire; with an armor belt of Harveyized steel 14 inches thick, and with main engines triple expansion, and a water consumption of probably less than 20 pounds per horse power hour, is using 146 steam cylinders for auxiliaries that are quite certain to consume more than 100 pounds of steam per horse power hour.

The worst feature of these conditions is that they exist when it can be certainly shown by calculation and from actual plants on land that an electric equipment would do the same work with less than 40 pounds of steam per horse power hour, and have less weight. Yet the "Iowa" has not been selected as a particularly bad example, but simply as a fair example of the great lack of electric power equipment in the navies of the world.

To sum up the case for electric driving in warships the following facts are pertinent: The electric motor, for hard and continuous work at all stages of load and overload, is in no way second to the steam engine, as shown by the tens of thousands of motors in use for electric traction under street cars, exposed to mud and water in all kinds of weather and to most severe overloads that would stall an engine in the same place and of equal rated capacity. Electric wires cut by shots in time of action simply put the apparatus to which they serve current out of use until the break is made good—usually but a matter of a very few minutes—while a steam pipe cut under the same conditions would be a serious menace to life in a close compartment, and would require much more time for repairs. Electric wires are so small and their temperature so nearly constant that they may be run about the ship with much less inconvenience and danger to other constructions, as men's quarters and water-tight compartments, than is the case with the much larger and hotter steam pipes.

For the same combined capacity of auxiliaries the complete weight of driving equipment from boiler to motor is less by a large percentage with electricity than with steam, as shown above. The electric system will deliver a horse power hour to the driven machinery with less than four-tenths the coal consumption necessary where individual steam engines are used.

The net result with the electric equipment, all other things being equal, is a lighter ship or greater coal capacity, a greater steaming radius or higher speed, and for ordinary operations in times of peace a material reduction in the yearly expense for coal. Of what value these features are to a great navy in peaceful maintenance or aggressive warfare, those whose positions impose the obligation may well decide.—The Engineer.

FIXATION OF CARBON BY PLANTS.*

THE subject which I have chosen for my address is the fixation of carbon by plants, one which is the common meeting ground of chemistry, physics and biology. I must, however, confine myself only to certain aspects of the question, since it is manifestly impossible to fully discuss the whole of a subject of such magnitude and importance within the time at my disposal.

We have become so accustomed to the idea that the higher plants derive the whole of their carbon from atmospheric sources that we are apt to forget how very indirect is the nature of much of the experimental evidence on which this belief is founded. There can, of course, be no doubt that the primary source of the organic carbon of the soil, and of the plants growing on it, is the atmosphere; but of late years there has been such an accumulation of evidence tending to show that the higher plants are capable of being nourished by the direct application of a great variety of ready-formed organic compounds, that we are justified in demanding further proof that the stores of organic substances in the soil must necessarily be oxidized down to the lowest possible point before their carbon is once more in a fit state to be assimilated.

It was the hope of gaining more direct evidence on this important question which led me some time ago to attack the problem experimentally in conjunction with Mr. F. Escombe, the resources of the Jodrell Laboratory at Kew having been kindly put at our disposal by Sir W. Thiselton-Dyer and Dr. D. H. Scott. Up to the present time our experiments have not been carried far enough to enable us to give a positive answer to the main question, but they have already suggested a new method of attack, which will enable us in the future to determine, with a fair amount of certainty, whether any particular plant, growing under perfectly natural conditions, derives any appreciable portion of its carbon from any other source than the gaseous carbon dioxide of the atmosphere.

During the course of the inquiry, many interesting side issues have been raised which we believe to be of some importance in their bearing on the processes of plant nutrition, and it is to a consideration of these that I intend to devote the greater part of my address.

I must, however, in the first place, indulge in a little historical retrospect, and am the more tempted to do this, as far as the early pioneers in this branch of knowledge are concerned, since a critical study of their writings has shown me very clearly that the relative merits of some of these older workers, and the respective parts which they took in founding the true theory of assimilation, have in our own time been much represented by more than one historian of science whose name carries great weight.

There is no chapter in the history of scientific discovery of greater abiding interest than that which was opened by Priestley in 1771, when he commenced his work on the influence of plants on the composition of the air around them. It has often been assumed that these experiments of Priestley, which were unquestionably the starting point for all succeeding workers, were the result of some haphazard method of working, and of one of those happy chances to which he is in the habit of attributing some of his most important discoveries. However much the element of chance entered into some of his work, and in this respect I think Priestley often does himself injustice, the discovery of the amelioration of vitiated air by plants was certainly not a case of this kind. Of all his contemporaries belonging to the old school of chemistry, Priestley had the clearest conception of the process of animal respiration and of their identity with the process of combustion. This is clearly shown by his "Observations on Respiration and the Use of the Blood," which he presented to the Royal Society in 1776. This memoir, written of course from the phlogistic point of view, only requires translating into the language of the newer chemistry to be an accurate statement of the main facts of animal respiration. We have it on Priestley's own authority that it was these studies which produced in his mind a conviction that there must be some provision in nature for dephlogisticating the air which was constantly being vitiated by the processes of respiration, combustion and putrefaction, and for rendering it once more fit for maintaining animal life. In his search for this compensating influence which he justly regarded as one of the most important problems of natural philosophy, he made many attempts to bring back the vitiated air to its original state by agitating it with water, and by submitting it to the continued action of light and heat, and it was in the course of these systematic attempts that he was led to study the influence of plants in this direction.

It was in the month of August, 1771, that he made the memorable experiments at Leeds of immersing sprigs of mint in air which had been vitiated by the burning of a candle or by animal respiration. To quote his own words, this observation led him "to conclude that plants, instead of affecting the air in the same manner with animal respiration, reverse the effects of breathing, and tend to keep the atmosphere sweet and wholesome when it is become noxious in consequence of animals either living or breathing, or dying and putrefying in it." That he was fully convinced that these observations, which he repeated and amplified in the following year, presented the true key to the problem, is sufficiently shown by another passage in which he says: "These proofs of the partial restoration of air by plants in a state of vegetation, though in a confined and unnatural situation, cannot but render it highly probable that the injury which is continually done to the atmosphere by the respiration of such a number of animals, and the putrefaction of such masses of both vegetable and animal matter, is, in part at least, repaired by the vegetable creation; and notwithstanding the prodigious mass of air that is corrupted daily by the above causes, yet if we consider the immense profusion of vegetables upon the face of the earth growing in places suited to their nature, and consequently at full liberty to exert all their powers, both inhaling and exhaling, it can hardly be thought but that it may be a sufficient counterbalance to it, and that the remedy is adequate to the evil."

Between the time of Priestley temporarily relinquishing his experiments in this direction in 1772 and his resumption of them in 1778, owing to the adverse criticism of Scheele and others, he had discovered dephlogisticated air or oxygen, and had elaborated his method for ascertaining the purity of air, or its richness in oxygen, by determining its diminution in volume after mixing with an excess of nitric oxide over water.* This method gave, of course, a much greater degree of precision to his results than was attainable in his earlier work, where the purity of the air at the end of an experiment was only determined by ascertaining if it would support the combustion of a candle or allow a small animal to live in it.

The results of his later work were published in 1779, and were not altogether confirmatory of those arrived at six years before. Is is true that he generally found evidence of an evolution of oxygen by the plants, but occasionally the air was less "pure" at the end of an experiment than it was at the beginning, and this occurred in a sufficient number of cases to Dr. Priestley to doubt to some extent the accuracy of his previous conclusions. On the whole, however, he still thinks it probable that the vegetation of healthy plants has a salutary effect on the air in which they grow.

The reason for this want of complete consistency in these later experiments was, of course, his failure at that time to recognize the important influence of light in bringing about the evolution of oxygen, an explanation which was given shortly afterward by Ingen-Housz.

Priestley's attention was now taken up with another observation, which led him within a very short distance indeed of the discovery that the evolution of oxygen by plants is conditioned, not only by a sufficient degree of illumination, but also by the pre-existence of carbon dioxide. It is the more necessary to treat of this point somewhat in detail, since it is a part of his work which has received but scanty justice at the hands of recent writers, who have apparently failed to see how much our modern conceptions of plant nutrition really owe to the initiative of Priestley. In his "History of Botany," Sachs deals very unfairly with Priestley in this respect, owing to a want of intimate knowledge of his writings, and to the lack of anything like perspective in estimating the relative merits of his contemporaries Ingen-Housz and Senebier, whose position can only be completely understood after a careful study of their numerous original memoirs, some of which are by no means readily accessible.

In the course of his experiments on plants partially immersed in water more or less fully impregnated with "fixed air," Priestley had observed a fact which had not escaped the notice of Bonnet at an earlier date, that bubbles of gas arose spontaneously from the leaves and stems, and it occurred to him that an examination of the nature of this gas by means of his new eudiometric process ought to settle the question whether plants really do contribute in any way to the purification of ordinary air. It was in June, 1778, that he put this to the test, and he found that the air thus liberated was much richer in oxygen than ordinary air. On removing the plants, he found to his astonishment, that the water in which they had been placed, and which had a considerable amount of "green matter" adhering to the sides of the phials, still continued to evolve a gas which increased in amount when the vessels were placed in sunlight. On testing this gas with his eudiometric process, he found that it consisted to a great extent of "dephlogisticated air" or oxygen; in fact, from the experimental results which he gives it is evident that the gas contained from 74 to 85 per cent. of oxygen. Having observed that the "green matter" appeared much more readily in pump water than in rain or river water, and knowing that pump water contained considerable amounts of "fixed air," he was led to make a series of experiments with water artificially impregnated with carbon dioxide, which left no doubt in his mind that the production of the "green matter," and the evolution of the dephlogisticated air were in some way due to the presence of "fixed air." Up to this point Priestley was following a path which seemed about to lead him to a complete solution of his previous difficulties. He had beyond all question succeeded in showing that the evolution of oxygen was not only dependent on the pre-existence of carbon dioxide, but that light was also required for the process. It only wanted, in fact, the recognition of the vegetable nature of the alga which constituted his "green substance" to bring these observations into line with his previous work, and to complete a discovery which would have eclipsed in importance all the others with which Priestley's name is associated. It was just this one step which he most provokingly failed to take. It is true that he examined the "green substance" under the microscope, but owing to want of skill in the use of the instrument, and also to his defective eyesight, he was unable to determine its true nature, and unfortunately adopted the view that it had merely a mechanical action in separating the oxygen from the water, and, to use his own words, that "it was only a circumstance preceding the spontaneous emission of the air from water." He was, in fact, now inclined to regard the process as a purely chemical one, due to the direct action of light on carbon dioxide dissolved in the water.

But this was by no means Priestley's final view, as shown by a further description of his experiments on plants set forth in the new edition of his works published in 1790, where he clearly recognized the error into which he had been led.* Meanwhile the subject had been taken up by two other observers, Ingen-Housz and Senebier, and in order to thoroughly understand the respective shares which these men took in advancing our knowledge of the assimilatory process, it is necessary to consult, not only their books, but also the numerous scattered memoirs which appeared at intervals between the years 1779 and 1800.

To Ingen-Housz must unquestionably be awarded the merit of having experimentally demonstrated that the amelioration of the surrounding air by plants is not, as Priestley at first believed, due to vegetative action per se, but is dependent on the access of light of a sufficient degree of intensity, and, moreover, that the power is confined to the green parts of the plants. At the same time, while recognizing, as Priestley had done before him, that the combined action of plants and light on the air was a dephlogisticating process, he did not know, until after its demonstration by Senebier, that the particular form of phlogisticated air which was essential to plants was "fixed air" or carbon dioxide. In fact, Ingen-Housz had but a slender knowledge of the chemistry of his day, so much so indeed that he constantly confuses "phlogisticated air" or nitrogen with "fixed air," and attributes the source of the evolved oxygen either to air imprisoned within the leaf, or, in the case of submerged plants, to a metamorphosis of the water itself. I must, however, recall the fact that Ingen-Housz was the first to show that the green parts of plants in the dark, and the roots both in the light and in darkness, vitiate the air in the same way as animals do. On the strength of

* Opening address by Dr. Horace T. Brown, F.R.S., President of the Chemical Section.

* Nitric oxide was discovered by Priestley in 1772, and was described by him under the name of "nitrous air."

* The view which was taken by Priestley's contemporaries of his position with regard to the discovery of the fundamental facts is well exemplified by the following remarks taken from a paper published by Ingen-Housz in 1781 (Annales de Physique, xxiv. 46). "C'est à M. Priestley seul que nous devons la grande découverte que les végétaux possèdent le pouvoir de corriger l'air mauvais et d'améliorer l'air commun: c'est lui qui nous en a ouvert la porte. J'ai été assez constamment attaché à ce beau système, dans le temps que lui même, par trop peu de prédilection pour ses propres opinions, paroissoit chanceler."

these experiments, he is generally given credit for having first observed the true respiration of plants, but I cannot avoid the conclusion that, in the controversy which ensued on this point between Ingen-Housz and Senebier, the adverse criticisms of the latter were well founded. Whilst not denying that plants in the dark have some mephitic influence on the air around them, Senebier maintained that the greater part of the observed effect was due to a fermentative action set up in the large bulk of leaves which Ingen-Housz employed. Certainly some of the results appear to be largely in excess of those we should now expect to obtain from respiratory processes only.*

Senebier's work falls between the years 1782 and 1800. The fact that he was an early convert to the new ideas and generalizations of Lavoisier gives his views on plant nutrition far greater precision than those of Priestley and Ingen-Housz. His experiments, for the most part well devised, proved beyond all doubt that the oxygen disengaged from submerged and isolated plants could not be derived from air contained in the leaf parenchyma, but that it depended on the pre-existence of carbon dioxide, and that its evolution was strictly proportional to the amount of carbon dioxide which the water contained

Although positive experimental proof was still wanting that aerial plants also derive their carbon from carbon dioxide, Senebier regarded this as extremely probable; but taking into consideration the small amount of this gas present in the atmosphere, he concluded that it must reach the plant by the roots and leaves entirely in a state of solution in water.

The work of Priestley, Senebier, and Ingen-Housz fortunately attracted the attention of a young chemist of high attainments, who, within a period of less than ten years, did more for the advancement of vegetable physiology than any single observer before or since his time. Theodore de Saussure, the second of that illustrious name, and the son of the famous explorer and natural philosopher, commenced his researches about the year 1796, and in 1804 published his "Recherches Chimiques sur la Végétation," a modest little octavo volume of some 300 pages which must certainly take rank as one of the great classics of scientific literature, and one of the most remarkable books of the century.

De Saussure was a past master in the art of experiment, and the methods which he devised for demonstrating the influence of water, air and soil on vegetation have been the models on which all such investigations have been conducted ever since. It is indeed very difficult, when reading this masterly essay, to bear in mind that it was not written fifty or sixty years later than the date on its title page, so essentially modern are its modes of expression and reasoning, and so far is the author in advance of his contemporaries. It is to this work we must refer for the first experimental proof that plants derive at any rate the greater part of their carbon from the surrounding atmosphere. This was shown by De Saussure by a variety of quantitative experiments of a sufficient degree of accuracy to bring out the great leading facts. By making known mixtures of carbon dioxide and air, and submitting them to the action of plants in sunlight, he was able, not only to show that the gaseous carbon dioxide was decomposed and the carbon assimilated, but also that the volume of oxygen disengaged was approximately equal to that of the carbon dioxide decomposed.† He also showed that plants growing in the open in moist sand, or in distilled water, and therefore under conditions in which they could not derive any carbon from other than atmospheric sources, not only materially increased in dry weight, but contained much more carbon at the close of the experiment than at the beginning, and had also fixed an appreciable amount of water in the process. That atmospheric carbon dioxide is not only beneficial to plants in sunlight, but is also essential to their very existence, De Saussure proved by introducing an absorbent of this gas into the vessel containing a plant or the branch of a tree rooted naturally in the soil. Under these conditions, the portions of the plant inclosed always died. He also ascertained by experiment the increase in dry weight of a sunflower plant during four months of natural growth; and knowing approximately the amount of water transpired during that period, and the maximum amount of solids which this transpired water could possibly introduce into the plant, he calculated that these solids, and the carbon dioxide in solution in the transpiration water, fell far short of accounting for the observed increase in the dry weight of the plant. This increase must, therefore, be mainly due to the fixation of atmospheric carbon dioxide and water.

It is certainly a remarkable fact that the rigid experimental proofs which De Saussure brought forward in support of his views did not carry conviction to the minds of every one. His book, however, suffered the fate of many others which have appeared in advance of their time. It is true that De Saussure's doctrines were always kept alive by the advanced physiologists of the French school, such as De Candolle and Dutrochet, but when Liebig first turned his attention to the subject he found the field in possession of the humus theory of Treviranus, a theory which no longer took any account of the decomposition of carbon dioxide by the leaves, but which derived the whole of the elements of the growing plant from a solution of the soil extract taken up by the roots. We may well say with Sachs, "Nothing can be conceived more deplorable than this theory of nutrition; it would have been bad at the end of the seventeenth century, it is difficult to believe that it could have been published thirty years after De Saussure's work." It is well known how by the cogency of his reasoning and the force of his genius Liebig successfully overthrew this heresy, and once more established the doctrine of carbon assimilation as taught by De Saussure; and the accurate work of Boussingault, who, whilst elaborating far more delicate analytical processes than were possessed by chemists in the early days of the century, still in the main used De Saussure's methods, gave the final death-blow to the humus theory, at any rate in the crude form in which it was presented by its originators. No one since that time has questioned the fact that green plants owe the greater part of their carbon to atmospheric sources, and the accumulated experience of two succeeding generations of workers has added proof on proof of the correctness of this great generalization.

But while it cannot be doubted that green plants devoid of parasitic or saprophytic habit derive the principal part of their carbon from the air, is the experimental evidence at present so complete as to exclude all other sources of supply? De Saussure himself certainly left the door open to such a possibility, and although Boussingault held a different view, we find Sachs as late as 1865 maintaining that it is not contrary to the generally accepted theory of assimilation to suppose that there are chlorophyllous plants which decompose carbon dioxide and at the same time absorb ready-formed organic substances whose carbon they utilize in the formation of new organs.

Up to comparatively recently there was little or no experimental evidence to justify this supposition, for the early experiments of De Saussure on the influence of solutions of sugar, and of other organic substances, on growing plants, although very suggestive, were not of a sufficiently precise nature to lead to any conclusions, and we must come down to within fifteen years of the present time for anything like a demonstration that the green organs of plants can, under favorable conditions, build up their tissue from already elaborated carbon compounds just as do the fungi and the non-chlorophyllous plants generally.

(To be continued.)

* It is by no means uncommon to find Ingen-Housz put forward as the discoverer of the fixation of carbon by plants from carbon dioxide. This claim is generally based on certain statements made in his essay on the "Food Plants and the Renovation of the Soil," published in 1796, as an appendix to the outlines of the fifteenth chapter of the "Proposed General Report from the Board of Agriculture." All that is good and sound in this essay is taken from Senebier's papers without any acknowledgment, but, in appropriating ideas which he evidently understands very imperfectly, he has built up a system of plant economy which is almost unintelligible.

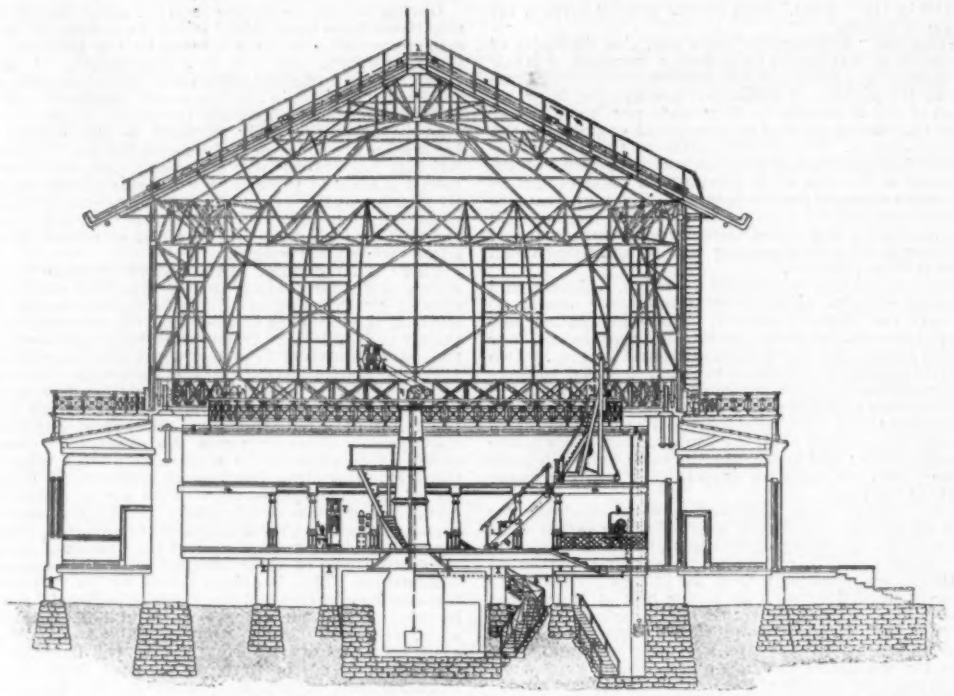
† Although clearly indicating that no change of volume occurred in the mixture of air and carbon dioxide so treated, his final analytical results show a small apparent evolution of nitrogen. This was due to the eudiometric methods he employed, methods, it is true, far superior in point of accuracy to those of his predecessors, but still necessarily imperfect.

P. Gamba reports in an Italian scientific paper that the operation of baking marble augments its flexibility, the augmentation increasing with the temperature and with the duration of the exposure. The residual deformation is also increased.

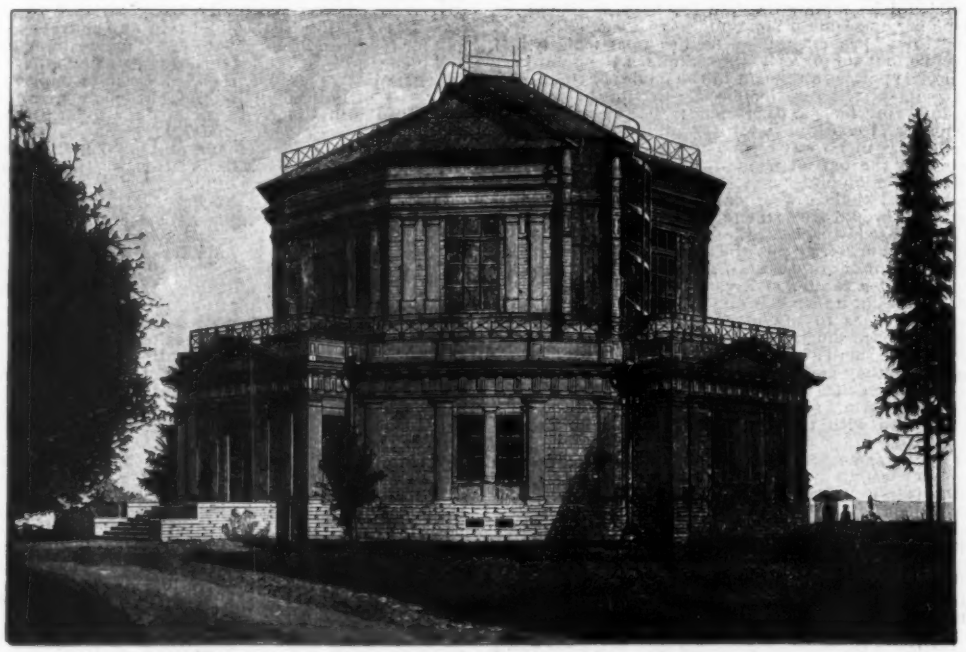
THE OBSERVATORY OF PULKOWA.

After Fraunhofer had formulated the principles which should govern the construction of large refracting telescopes, it became the task of the telescope maker, in improving the instruments then in use, to adapt the technical skill of modern times to the steadily increasing requirements of the astronomer. But, owing to their great cost, very large instruments are few in number. On the other hand, the demand for smaller instruments has increased; for many wealthy patrons of astronomy have devoted themselves to the study of the heavens. There are a certain number of firms engaged only in the making of small refractors, which, owing to the care taken in their construction, are very efficient and trustworthy instruments.

The first of the series of large refractors built was the telescope at the Naval Observatory at Washington, mounted by Warner & Swasey, of Cleveland, O. The objective of this instrument has an aperture of 26 inches; the focal distance is 30·5 feet. The telescope consists entirely of riveted steel plates, has a length of over 36 feet, and cost, with its auxiliary apparatus, $46,000. A few years later the large refractor of the Vienna Observatory, with its objective of 27 inches aperture, was built. The lenses of this instrument, like those of most modern large refractors, were made by Alvin Clark & Sons and the mounting by Sir Howard Grubbs, of Dublin. At present, this is the third largest astronomical telescope in Europe. The Bischoffsheim Observatory telescope on Mont Gros, near Nice, with an objective having an aperture of 29 inches, and the refractor of Pulkowa, with an aperture of 30 inches, are the largest instruments which have yet been constructed. It might, perhaps, be asked what advantage these modern instruments have over their more modest predecessors, with which so many brilliant discoveries were made? Everyone who has looked at a fixed star through an astronomical telescope will have observed that it appeared rather smaller than when viewed with the naked eye; for it has been reduced to a shining point by the disappear-



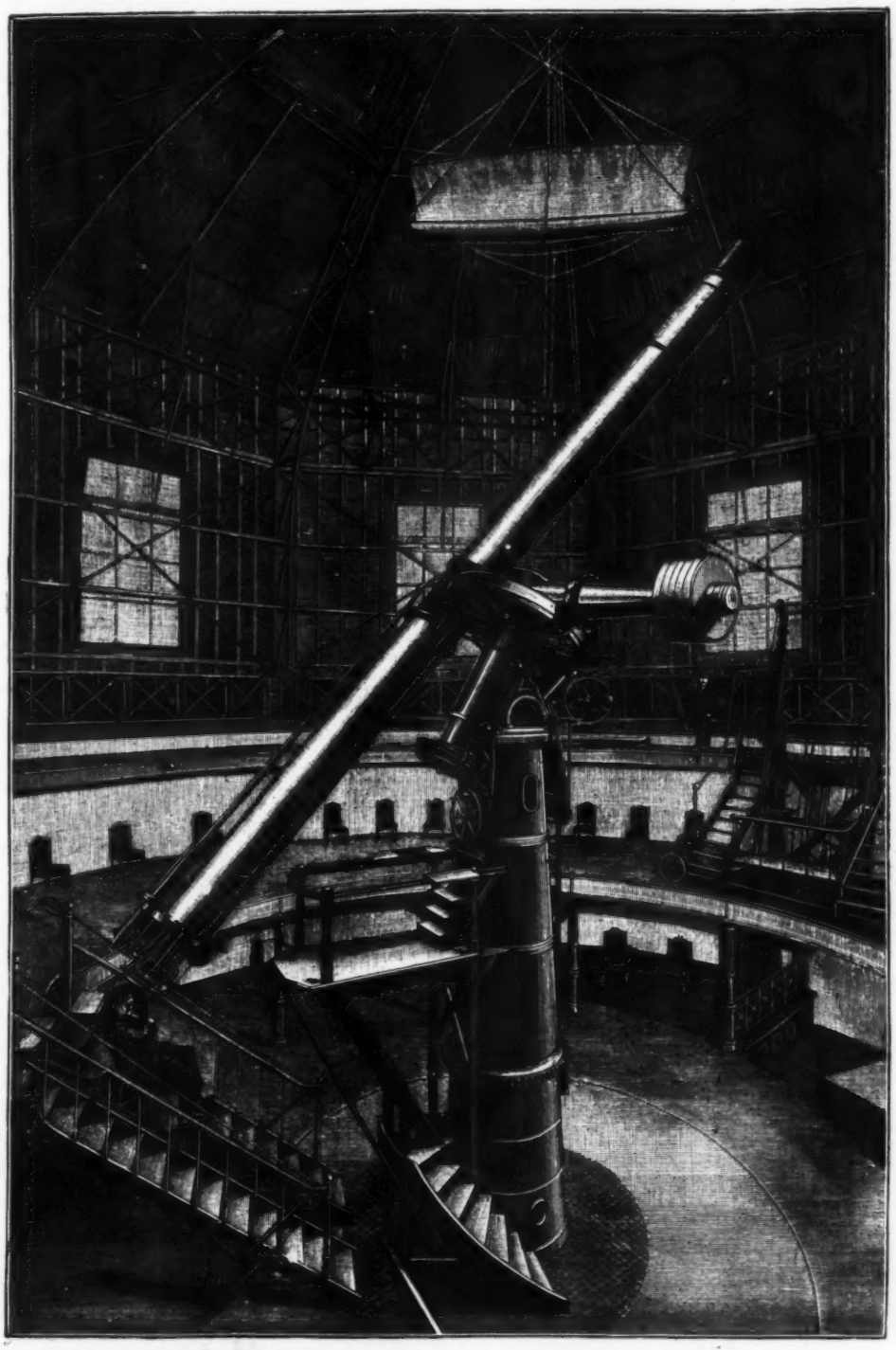
SECTION OF THE OBSERVATORY OF PULKOWA.



THE GREAT OBSERVATORY OF PULKOWA.

ance of the rays. If high-power telescopes be used, the increased magnifying power has an effect upon the atmosphere as well as upon the star, with the result that the image is not stationary; it apparently trembles and therefore interferes considerably with astronomical observations. The vibration of the image, the magnifying power being the same, is less noticeable in smaller than in large instruments, i. e., their "definition" is better.

We now come to the largest telescope which has yet been constructed in Europe—the 39-inch refractor of the Imperial Observatory at Pulkowa. The instrument is supported on an iron pier rising from a foundation of brick. The pier is of cast iron, and is made in seven parts, bolted together, two of which are embedded in the foundation. The base is a hollow cone, firmly cemented to the foundation. The upper end of the pier consists of a box-like body having a plate parallel to the polar axis. The correction for declination is made by two screws; that in azimuth by turning the



THE 30-INCH REFRACTING TELESCOPE OF THE PULKOWA OBSERVATORY.

uppermost conical portion of the pier by means of set screws. The polar axis is journaled on the pier, and its form is essentially that of a cylinder. A clock is provided which turns the polar axis at the rate of one revolution in a sidereal day. At its lower end the polar axis carries micrometer microscopes for fine readings of the lower hour circle. The upper hour circle gives the coarse reading.

The polar axis (made of Krupp gun steel) is journaled in two cylindrical bearings and is supported longitudinally by the lower bearing. The polar axis is driven by a gear wheel at its lower extremity, which wheel engages another gear operated by a hand wheel. Above the polar axis the declination axis is mounted. The end thrust of the polar axis is taken up by a vertical disk inserted in a groove above the upper trunnion of the axis. This disk is located beneath the center of gravity of all the parts immediately connected with the polar axis, and, therefore, relieves the bearings of much of the weight which would otherwise fall upon them. The disk is horizontally journaled on a support, one end of which bears on the upper extremity of the pier, and the other end of which is adapted to be raised by a lever fulcrumed beneath the support. The long arm of this lever is counter-poised by a chain extending to the foundation. The polar axis is provided with a longitudinal channel or recess in order to permit the adjustment of the instrument in declination from the lower end of the polar axis.

The telescope itself consists of a central drum of cast iron to which two sheet steel tubes are riveted. The thickness of the steel decreases from the objective to the eyepiece. The tubes are of different length. The eyepiece end has been made as short as possible so that the observer will not be required to change his position too frequently. At the eyepiece end are two openings controlled by shutters, which openings are provided for cleaning purposes. The mounting of the objective has also been provided with openings in six different places so that the inner lenses, separated from each other by about 15 centimeters, can be readily cleaned. The first mentioned openings in conjunction with orifices at the eyepiece end can be used for ventilating the tubes. If it arouse astonishment to see this huge telescope poised like a slender rod on its support, responding to every pressure of the finger, how much more perplexing must the complicated construction of the eyepiece end appear with its innumerable appliances for the making of correct observations.

Owing to the size of this instrument and of the observatory in which it is housed the astronomer is usually assisted by three men of whom two are engaged in recording the observations made and in adjusting the telescope, and the third in adjusting the observing stand of the observer and the moving parts of the observatory.—Stein der Weisen.

Great Britain's post office authorities are considering the question of doing away with postage stamps entirely and using some form of automatic canceling machine instead.

THE PRODUCTION OF RUBBER IN THE AMAZONS.

THE principal rubber bearing areas in the State of Para are the islands of the River Amazon near the city, the principal Marago, having an area of 2,500 square miles; the banks of the river Tocantins; the banks of the rivers Zingu, Jary, and Tapajos. The upper and lower districts of the Amazon produce the same kind of rubber, but that coming from the upper river obtains a slightly higher price, being dryer by the time it reaches the port of shipment.

The collecting season for rubber in the Lower Amazons begins when the waters have subsided—about July—and ends in January or February. Collecting is not undertaken, as a rule, in the wet season, because the quantity of water that accumulates in the forest impedes the movements of the collectors, and the rain water that runs on the trunks of trees prevents the clay cups from adhering to the bark. The sap is also weaker in this season. The United States consul at Para, in a recent report, says that the collectors employed are principally Brazilians, immigrants from the States bordering on Para, such as Ceara, Maravham, and Piauhy, also Portuguese and half-castes. The pure South American Indian is of very little use as a laborer. He has but few wants, lives by fishing and hunting, and is less dependent on labor than more civilized people. There are many thousands of collectors in the rubber field, yet the number does not supply the demand.

The last few years have shown a steady and rapid increase in the exports of rubber, and while labor has also gradually increased, it has failed to keep pace with the fast growing demand. Among other articles used in the Indian rubber industry is a clay funnel, in shape very much like an ordinary toilet water jug without a bottom or handle. It is made of the clay that is found in most parts of the Amazon region. The fuel used in the funnel consists generally of the nuts of the following palms: Native names—"Urucuri," "Tucuma," "Inaga"; botanical names—Attalea, Astrocaryum, and Maximiliana regia. It was at one time imagined that the excellence of Para rubber was greatly due to the kind of fuel used in curing it. The palms that furnish the fuel were accordingly transplanted to Africa, with a view to the production of Para rubber there. The experiment, however, has not met with success. The reason these nuts are selected in Brazil is because they emit a continuous dense smoke, and are more portable than other fuel obtainable. However, when none of the palms named are accessible, bark and twigs are used as fuel.

Everyone engaged in the forest carries a knife. One of its uses is to cut down fuel for the preparation of rubber. The blade is about 26 inches long and about 2 inches broad. Owing to the damp climate, the blades are electro-plated, thus preventing their becoming rusty before they are marketed. The handles are made of wood, and are carved or inlaid with brass. The rubber collector's axe is a very small affair. It is required to clip a smooth surface on the bark preparatory to attaching a cup to the tree. The handling of the axe requires great skill, in order not to injure the bark. A smooth surface is made in order to prevent impurities from mixing with the sap. The cups are of clay or tin. The former are attached to the bark by means of a little clay. Their weight, however, makes them inconvenient to carry when the trees to be tapped are separated by long intervals; the collector then prefers to carry tin cups, which are much lighter than the others. They easily penetrate into the bark by means of their sharp edges, and hold to the tree without the use of clay. The use of the tin cup, however, is to some extent injurious to the tree.

Part of the collector's outfit consists of a light gourd, large enough to carry the contents of from 500 to 700 cups. A clay bowl is next required in order to receive the contents of the gourd. It is of sufficient size to contain the product of several days before it is cured. The calabash tree provides calabashes which are employed to ladle the milk from the clay bowl into the mould. A broad-bladed wooden paddle is used as a mould, and is made locally. This completes the outfit for the rubber collector. All these articles are made locally, with the exception of the knives. The axes and the tin cups are manufactured in the towns and villages of the Amazon region. The collector has to use his knife to cut his way through the undergrowth, and also to cut down a sapling occasionally to bridge a rivulet. At times he is knee-deep in ooze or up to his waist in water. On arrival at a rubber tree, he chips away the rough parts of the bark, makes a more or less smooth surface, attaches a cup and makes a small gash above for the sap to fall into the cup, and repeats this process in a line round the tree until he has attached six or seven cups. Then he proceeds to the next tree and does the same. He continues this process until he has tapped from 75 to 150 trees, which can be done in a day, if they are not too far apart.

On the following days the gashes in the trees are made a trifle lower down than the first ones. Some collectors tap the trees in the morning, and return to collect the sap in the evening, whereas others tap in the evening, and collect in the morning. An expert gathers seven pounds daily in the Lower Amazon; in the Upper Amazon three times this amount is collected. When the accumulated rubber is sufficient—usually in three or four days—a collector lights a fire in the hut he has erected, places the funnel over the fire, pours a thin coat of milk over the paddle, and holds it over the smoke to coagulate. The process is repeated until a large cake has been formed. To release the paddle from the cake, it is necessary to make a slit on one side. The paddle mould makes a cake of uniform and even shape, and is in general use in the State of Para. In other parts, a spit is placed on two upright forked sticks, and given a rotary motion. By this means, the rubber is cured with greater ease. Paddle-smoked rubber is decidedly preferred, as it is dried and seemingly more carefully cured.

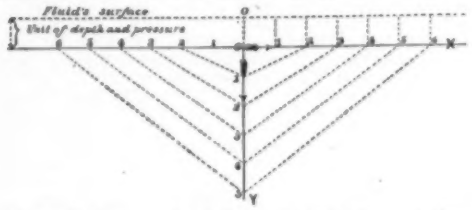
Many attempts have been made to introduce improved curing apparatus. Up to the present, however, the efforts have not been successful, because the common method, although very primitive, possesses the advantage of being simple and inexpensive. The process of curing rubber is found to be very injurious to the eyes. Many cases of total blindness result from it. There are three grades of Para rubber,

viz., fine, medium and coarse. If rubber is not uniform, and contains impurities, it is classified as medium. The coarse quality, or "Sernamby," consists of scraps that have not been cured. Insufficient labor is the most serious difficulty in the rubber industry. Consul Kenneday says that it would scarcely seem advisable to invest money in rubber estates unless the owner can first see his way clear to obtain sufficient labor with which to collect the rubber.—Journal of the Society of Arts.

PROPER FORMS FOR CROSS SECTIONS OF MOVING BODIES.

Accepting the fact that the secondary or displacing forces, created by the impelling force and the resistance of the fluid, radiate equally in all directions in their plane of action, it follows, that if the inward resistance of the fluid to these forces also acts equally from all directions, the line marking their limit of action will be the periphery of a circle. Hence, in all cases where the object moves in the lines of gravity, or perpendicular directions, its transverse section should be a circle. Also, when the object moves through the air horizontally, its cross section can be circular, as the difference of pressure, due to difference of levels of upper and lower edges, will not be sensible.

In all fluids subjected to the action of gravity the pressure increases directly as the depth. In water this increase of pressure is very perceptible, being about 62½ pounds per foot; about 64 pounds in salt water. In any liquid, take any definite distance beneath its surface as the unit of measure, and the pressure of the fluid which corresponds with this depth, as the unit of resistance. With this unit of measure lay off on a set of rectangular axes (the continuation of the perpendicular distance, and the horizontal line passing through the end point of unit of measure) equal intervals from their point of intersection or origin.



Suppose two equal forces to act simultaneously from the origin along the axis; it is evident that the one acting along the horizontal axis will encounter a constant resistance due to the depth of this axis below the surface. Each interval passed through adding one unit of resistance to that already encountered. The force acting downward overcomes a unit of resistance in each interval passed through plus the total pressure, or resistance of the previous units.

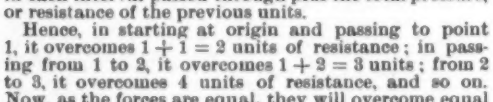
Hence, in starting at origin and passing to point 1, it overcomes 1 + 1 = 2 units of resistance; in passing from 1 to 2, it overcomes 1 + 2 = 3 units; from 2 to 3, it overcomes 4 units of resistance, and so on. Now, as the forces are equal, they will overcome equal amounts of resistance in equal periods of time; so when the downward force arrives at point 1, the horizontal force will have arrived at point 2; and when the first force reaches point 2 the second force reaches point 3, and so on. This establishes the ratios between the perpendicular and horizontal intervals, as follows:

1 : 2 = 1 : 2
2 : 3 = 1 : 1½
3 : 4 = 1 : 1⅓
4 : 5 = 1 : 1¼
5 : 6 = 1 : 1⅕
etc. etc.

This establishes a decreasing series of ratios between the limits of 1 : 2 and 1 : 1. This series only embraces motion to the right along the horizontal line or axis, if another equal force be supposed to act from the origin to the left, then the second member of the ratios is doubled and the limits would be 1 : 4 and 1 : 2. From this it follows that the nearer the surface of a fluid the object approaches, the wider the cross section should be in proportion to its depth, but never exceeding the ratio of 4 to 1; and, the deeper down the object moves the narrower the section in proportion to its depth, yet never reaching the limit of 2 to 1.

The ratios being established, the shape of that part of the cross section falling below the horizontal axis can always be determined. This is always a prolate semi-ellipse for every ratio.

Take the first ratio, 1 : 2.



Take $O\,A$ as the unit of measure, and then the pressure, or resistance due to this depth is one. On the perpendicular axis lay off $A\,y$, equal to $A\,O$. Through y draw the line $y\,c$ parallel to $A\,X$; and through X and g, the middle point of $A\,X$, draw lines parallel to $A\,y$; then will we have the parallelograms or rectangles, $A\,c$ and $A\,b$. Draw the diagonals $A\,b$ and $A\,c$, and ascertain their lengths:

$$A\,b = \sqrt{2} = 1{\cdot}4142\,;\ A\,c = \sqrt{5} = 2{\cdot}2360.$$

Also, the angles; $b\,A\,g = 45°$, N. sine = 0·70711. N. cosine = 0.70711; $c\,A\,X = 26° - 34'$, N. sine = 44724; N. cosine = 0·89441. The forces acting down the diagonals are to be considered in this problem as the resultants of the perpendicular and horizontal forces. In this case $A\,y = 2$, and $A\,X = 2$ units of force. Ascertaining the value of the resulting forces, and reducing them all to percentages by dividing by 2, we have $A\,y = 1{\cdot}00$ per cent.; $A\,b = 1{\cdot}118$ per cent.; $A\,c = 1{\cdot}4142$ per cent.; and $A\,X = 100$ per cent. Let d be the distance traversed by the respective forces in a unit of time; then we have the proportions—

$d : 1 : : 1 : 1{\cdot}00$ per cent., $d = 1 = A\,y$;
$d : 1{\cdot}4142 : : 1 : 1{\cdot}118$ per cent., $d = 1{\cdot}264 + = A\,e$;
$d : 2{\cdot}2360 : : 1 : 1{\cdot}4142$ per cent., $d = 1{\cdot}581 + = A\,f$;
and $d : 2 : : 1 : 1{\cdot}00$ per cent., $d = 2 = A\,X$.

The respective distances from the origin, A, of the points y, e, f, and X, being known, it remains to be seen if they lie in the arc of a regular curve. Any curve can be made to pass through three points; so it takes at least four points to determine a special curve. Making $A\,X$ equal to A, and $A\,y$ equal to B, the semi axes of an ellipse, the points, X and y, are fixed or determined in the curve. Now, if the coördinates of the points, e and f, also satisfy the equation of the ellipse, $A^2\,7^2 + B^2\,x^2 = A^2\,B^2$, the ellipse will be the curve required. Multiplying the diagonal distances by sine and cosine of their respective angles, will give the coördinates; hence, for point e:

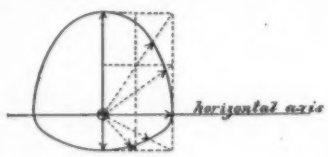
$x = 1{\cdot}264 \times 0{\cdot}70711 = 0{\cdot}8937744\,;\ x^2 = 0{\cdot}7988148 +$
and $7 = 1{\cdot}264 \times 0{\cdot}70711 = 0{\cdot}8937744\,;\ 7^2 = 0{\cdot}7988148 +$
$A^2 = 4\,;\ B^2 = 1\,;\ A^2\,B^2 = 4.$
$A^2\,7^2 = 3{\cdot}195259 +$, or $A^2\,7^2 + B^2\,x^2 = 4.$
$B^2\,x^2 = \dfrac{0{\cdot}798814 +}{3{\cdot}994073 +}$ $\qquad 3{\cdot}99 + = 4.$

For Point f.

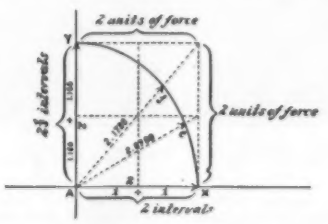
$x = 1{\cdot}581 \times 0{\cdot}89441 = 1{\cdot}714 +\,;\ x^2 = 1{\cdot}9999 + = 2.$
$7 = 1{\cdot}581 \times 0{\cdot}44724 = 0{\cdot}7071 +\,;\ 7^2 = 0{\cdot}49999 + = 0{\cdot}5.$
$A^2\,7^2 = 4 \times 0{\cdot}5 = 2\,;$ or $A^2\,7^2 + B^2\,x^2 = 4.$
$B^2\,x^2 = 1 \times 2 = \dfrac{2}{4}$ $\qquad 2 + 2 = 4.$

As the coördinates of the points e and f satisfy the equation of the ellipse, it is the curve formed by the action of the equal forces radiating from the point, A, at any depth below the surface. If any other ratio between the length of axes had been assumed, the curve generated under like conditions would be an ellipse. The shape of the part of the cross section of the immersed body below the horizontal axis having been proved to be a prolate semi-ellipse.

It can also be proven that the part above the horizontal axis is an erect semi-ellipse. Hence, by combining the prolate semi-ellipse with the erect semi-ellipse, we have the proper shape for the entire cross section. The reason that the upper section is an erect semi-ellipse instead of prolate is because an equal force moving upward against a uniformly diminishing resistance will move further than where the resistance is constant, or along the horizontal axis. The cross section thus evolved is the theoretical cross section of a fish, or would be if the fish swam constantly at the same level. Thus—



The proof that the part of the immersed transverse section above the horizontal axis is an erect semi-ellipse is as follows: Divide the units of measure and resistance into any number of equal parts, say ten. Now, what is true of a part is true of the whole, and conversely; hence the same ratios that existed between the units will exist between the parts. And, again, these equal fractional divisions can be treated as whole numbers, as they all have the same denominator. Now, from the fact that for every unit in depth that the force descends it encounters an additional unit of resistance, it follows that for every unit it ascends a unit of resistance is substracted. Hence, in ascending $\frac{1}{10}$ intervals it encounters $\frac{1}{10}$ less resistance than if moving horizontally under constant resistance. In moving up through the second interval it encounters $\frac{2}{10}$ less resistance than if moving through second intervals along the horizontal axis, and so on. Hence, the force that would move through 2 intervals along the horizontal axis will move through $2\frac{2}{10}$ intervals up the perpendicular axis. In moving through the extra $\frac{1}{10}$ intervals, it gains $\frac{1}{10}$ of $\frac{1}{10}$, or 0·03, and in moving through the 0·03 it gains 0·003 more, and so on; so that the force that would move through 2 intervals on the horizontal axis moves up the perpendicular axis two and one-third intervals, $2\frac{1}{3}$. Hence, the perpendicular axis, which was the minor axis in the first case, becomes the major axis, and the prolate semi-ellipse becomes an erect semi-ellipse. By constructing a diagram and proceeding as before, and using units instead of tenths, we have a problem similar to the first.



$<e\,A\,X = 30° - 15'$, N. sine = 0·75984; N. cosine = 0·65011.
$<f\,A\,X = 49° - 27'$, N. sine = 0·50377; N. cosine = 0·86384.

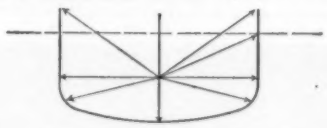
For Point f.

$x = 2{\cdot}1730 \times 0{\cdot}75984 = 1{\cdot}651132 +\,;\ x^2 = 2{\cdot}7261 +$
$7 = 2{\cdot}1730 \times 0{\cdot}65011 = 1{\cdot}4128\,;\ 7^2 = 1{\cdot}996 +$
$A^2 = 5{\cdot}4444 +\,;\ B^2 = 4\,;\ A^2\,B^2 = 21{\cdot}7777 +$
$A^2\,7^2 + B^2\,x^2 = 21{\cdot}7777$
$10{\cdot}8652 + 10{\cdot}904 = 21{\cdot}7696 + = 21{\cdot}7777.$

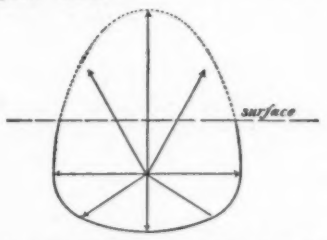
Point e

$x = 2{\cdot}0709 \times 0{\cdot}50377 = 1{\cdot}043257 +\,;\ x^2 = 1{\cdot}08837 +$
$y = 2{\cdot}0709 \times 0{\cdot}86384 = 1{\cdot}788926 +\,;\ 7^2 = 3{\cdot}198732 +$
$A^2\,y^2 + B^2\,x^2 = A^2\,B^2$
$17{\cdot}4150 + 4{\cdot}3534 = 21{\cdot}76848 + = 21{\cdot}7777$

The forms for the transverse section of a moving body wholly immersed in a fluid, having been determined for two directions, perpendicular and horizontal, it remains to be seen, what should be the shape of the section when the body is only partly immersed, or when it moves at the fluid's surface. This is the most difficult case to arrive at a satisfactory conclusion; for, if we take the axis of motion at the surface, we have no resistance to create radiating secondary forces; hence there is no displacement. But, if we take the axis of motion beneath the surface we have a modified form of the previous case, where the object is wholly immersed. In this instance, if we consider the upward force to be greater than the resistance of the fluid intervening between the axis of motion and the surface, we find that after the resistance is overcome the remaining force continues to act upward indefinitely. And if the semi-axis is prolonged far enough, the sides of the ellipse meeting the prolate section could be considered as perpendicular. Thus—



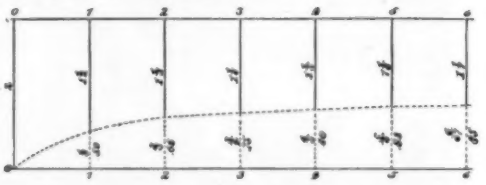
Then again, if we consider the upward force limited in its action, the elliptical axis is limited, and we would have the same case as when the object is entirely immersed; only the erect semi-ellipse would be much higher. Thus—



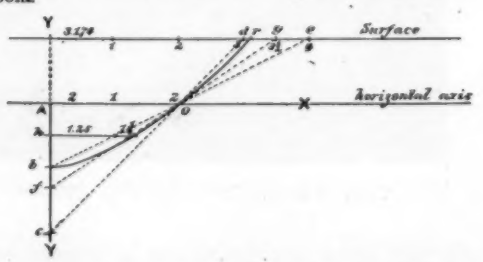
This latter case is the correct shape for a boat's cross section, if the load line is constant and there is no wave action, or where the draught of vessel is constant.

As wave action causes a variation of pressure at moderate depths below the surface, it has the same effect as alternating the draught of a vessel from one level to another. To find a section suitable to such alternation of draught or pressure is the last problem to solve; this necessarily must be a compromise of any fixed conditions.

We have already seen that the limits of the series of ratios, expressing variations of width to depth, are 2 : 1 and 1 : 1. To obtain a graphic representation of this change of ratios, lay off on a straight line equal intervals; at each point so obtained erect perpendiculars expressing the different ratios in their lengths in terms of the unit of measure.



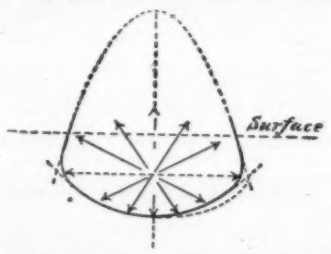
Passing a line through their extremities, we can readily see that it forms a curve, and as the limit of the ratio 1 : 1 is never reached in any finite distance, the curve never becomes parallel to the axis within that limit, and hence it is impossible to assign A and B in the equation of an ellipse any fixed value. Taking the equation of a parabola of the third order, $y^3 = a\,x$, make $y = 0{\cdot}75$ and $x = 3$, and a will then be equal to 0·140925; substituting this value of a in the equation we have $y^3 = 0{\cdot}140925\,x$. Making x equal to 1, 2, 3, 4, successively, we have y equal to 0·52; 0·555 +; 0·75; and 0·82, which closely approximates the real values; and hence this curve very nearly represents the variation of the ratios. By making a hyperbola pass through three of the points, the variation at the fourth point will be still greater than with the parabola.



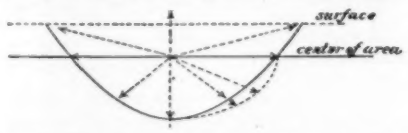
Draw a set of rectangular axes with the origin at a unit's depth below the surface. On $A\,X$ take the point, o, two units from A, and on $A\,Y$ take the point, b, one unit from A, and the point, c, two units from A; through o draw lines, $b\,e$, and $c\,d$, cutting the surface at points e and d, 4 and 3 units distant from the perpendicular axis. From the point g, the middle of $d\,e$, draw the line, $g\,f$, through o. The line, $b\,o$, cutting the surface at e, gives the extreme point at the surface due to the ratio of 1 to 2. The line, $c\,o$, cutting the surface at d, gives the opposite extreme due to the ratio of 1 to 1. All intermediate ratios formed at the axis fall between these points, d and e. Find a curve that will pass through b, d, and o, and which can be constructed on the given axes (the arc of any curve can be made to pass through these points without regard to the generating axes). An equation of a parabola will again approximate the conditions nearer than any other curve. Locating a fourth point, k, by drawing a line through

the middle of *A b*, parallel to *A X*, and prolonging it till it intersects *g f* at *k*, we have the coördinates of point *b* equal to zero; for point *K*, $x = 0{\cdot}5$, $7 = 1{\cdot}25$; for *o*, $x = 1$, $7 = 2$; for point *d*, $x = 2$, $7 = 3$. Substituting the values of x into the equation of a parabola, $y^{\frac{1}{2}} = ax$, or $y^{\frac{1}{2}} = \sqrt{8} \times x$, we get $x = o$, $7 = o$; $x = \frac{1}{2}$, $7 = 1{\cdot}25$; $x = 1$, $7 = 2$; $x = 2$, $7 = 3{\cdot}174$— this equation fulfills the conditions, as the curve ought not to pass through the point *d*, as it is the limit of the ratio 1 : 1, a limit that is never attained.

To make a practical application of this curve, use it in the same manner as the ellipse in the previous case, letting the part of section below the horizontal axis have the form of a parabola and the section above this axis have the form of a reversal parabola. Thus—



As the parabolic curve lies within the elliptical curve generated on the same axes, it requires the same amount of power to propel it, but gives less flotation or tonage, and changes the friction coefficient from one due to adhesion to one due to cohesion. If the entire cross section be given the form of a parabola, the section above the horizontal axis will not conform to the limits of the forces, but has the advantage of maximum stability, and by transferring the greater part of the flotation near the surface, also has the advantage of presenting the greatest area of cross section to the area of least resistance of the fluid. Thus—



Theoretically the less the draught the better, and this is always the case where there is a calm surface, but in the case of heavy swells, depth is an advantage, rather than a detriment.

The best examples in nature of the elliptical cross-sections, and their corresponding paraboloidal developments are the under bodies of swans, wild geese and ducks, when swimming in the water. When walking on the land their forms are greatly altered in outline.

The parabolic lines of the breast are not so prominent in the tame birds. The cross sections of fish exemplify the immersed sections. The circular section is not found in nature, not being adapted to horizontal motion. Theoretically, it is only possible when the depth and width become equal at infinity.

M. F. MITHOFF.

THE PROGRESS OF SCIENCE AND ITS RESULTS.*

By Prof. SIR MICHAEL FOSTER, K.C.B., Sec.R.S.

HE who until a few minutes ago was your President said somewhere at the meeting at Bristol, and said with truth, that among the qualifications needed for the high honor of the Presidency of the British Association for the Advancement of Science that of being old was becoming more and more dominant. He who is now attempting to speak to you feels that he is rapidly earning that distinction. But the Association itself is older than its President; it has seen pass away the men who, wise in their generation, met at York on September 27, 1831, to found it; it has seen other great men who in bygone years served it as Presidents, or otherwise helped it on, sink one after another into the grave. Each year, indeed, when it plants its flag as a signal of its yearly meeting, that flag floats half-mast high in token of the great losses which the passing year has brought. This year is no exception; the losses, indeed, are perhaps unwontedly heavy. I will not attempt to call over the sad roll-call; but I must say a word about one who was above most others a faithful and zealous friend of the Association. Sir Douglas Galton joined the Association in 1860. From 1871 to 1895, as one of the General Secretaries, he bore, and bore to the great good of the Association, a large share of the burden of the Association's work. How great that share was is perhaps especially known to the many men, among whom I am proud to count myself, who during his long term of office served in succession with him as brother General Secretary. In 1895, at Ipswich, he left the post of General Secretary, but only to become President. So long and so constantly did he labor for the good of the Association that he seemed to be an integral part of it, and meeting as we do to-day, and as we henceforward must do, without Douglas Galton, we feel something greatly missing. This year, perhaps even more than in other years, we could have wished him to be among us; for to-day the Association may look with joy, not unmixed with pride, on the realization of a project in forwarding which it has had a conspicuous share, on the commencement of an undertaking which is not only a great thing in itself, but which we trust is the beginning of still greater things to come. And the share which the Association has had in this was largely Sir Douglas Galton's doings.

In his address as President of Section A, at the meeting of the Association at Cardiff in 1891, Prof. Oliver Lodge expounded with pregnant words how urgently not pure science only, but industry and the constructive arts—for the interests of these are ever at bottom the same—needed the aid of some national establishment for the prosecution of prolonged and costly physical researches, which private enterprise could carry out in a lame fashion only, if at all. Lodge's words found an echo in many men's minds; but the response was for a long while in men's minds only. In 1895 Sir Douglas Galton, having previously made a personal study of an institution analogous to the one desired—namely, the Reichsanstalt at Berlin—seized the opportunity offered to him as President of the Association at Ipswich to insist, with the authority not only of the head for the time being of a great scientific body, but also of one who himself knew the ways and wants at once of science and of practical life, that the thing which Lodge and others had hoped for was a thing which could be done, and ought to be done at once. And now to-day we can say it has been done. The National Physical Laboratory has been founded. The address at Ipswich marked the beginning of an organized effort, which has at last been crowned with success. A feeling of sadness cannot but come over us when we think that Sir Douglas Galton was not spared to see the formal completion of the scheme whose birth he did so much to help, and which, to his last days, he aided in more ways than one. It is the old story—the good which men do lives after them.

Still older than the Association is this nineteenth century, now swiftly drawing to its close. Though the century itself has yet some sixteen months to run, this is the last meeting of the British Association which will use the numbers eighteen hundred to mark its date.

THE POSITION A HUNDRED YEARS AGO.

The eyes of the young look ever forward; they take little heed of the short though ever-lengthening fragment of life which lies behind them; they are wholly bent on that which is to come. The eyes of the aged turn wistfully again and again to the past; as the old glide down the inevitable slope their present becomes a living over again the life which has gone before, and the future takes on the shape of a brief lengthening of the past. May I this evening venture to give rein to the impulses of advancing years? May I at this last meeting of the Association in the eighteen hundreds dare to dwell for a while upon the past, and to call to mind a few of the changes which have taken place in the world since those autumn days in which men were saying to each other that the last of the seventeen hundreds was drawing toward its end?

Dover in the year of our Lord seventeen hundred and ninety-nine was in many ways unlike the Dover of to-day. On moonless nights men groped their way in its narrow streets by the help of swinging lanterns and smoky torches, for no lamps lit the ways. By day the light of the sun struggled into the houses through narrow panes of blurred glass. Though the town then, as now, was one of the chief portals to and from the countries beyond the seas, the means of travel were scanty and dear, available for the most part to the rich alone, and, for all, beset with discomfort and risk. Slow and uncertain was the carriage of goods, and the news of the world outside came to the town—though it from its position learned more than most towns—tardily, fitfully, and often falsely. The people of Dover sat then much in dimness, if not in darkness, and lived in large measure on themselves. They who study the phenomena of living beings tell us that light is the great stimulus of life, and that the fullness of the life of a being or of any of its members may be measured by the variety, the swiftness, and the certainty of the means by which it is in touch with its surroundings. Judged from this standpoint, life at Dover then, as indeed elsewhere, must have fallen far short of the life of to-day.

The same study of living beings, however, teaches us that while from one point of view the environment seems to mould the organism, from another point the organism seems to be master of its environment. Going behind the change of circumstances, we may raise the question, the old question, Was life in its essence worth more then than now? Has there been a real advance?

Let me at once relieve your minds by saying that I propose to leave this question in the main unanswered. It may be, or it may not be, that man's grasp of the beautiful and of the good, if not looser, is not firmer than it was a hundred years ago. It may be, or it may not be, that man is no nearer to absolute truth, to seeing things as they really are, than he was then. I will merely ask you to consider with me for a few minutes how far, and in what ways, man's laying hold of that aspect of or part of truth which we call natural knowledge, or sometimes science, differed in 1799 from what it is to-day, and whether that change must not be accounted a real advance, a real improvement in man.

I do not propose to weary you by what in my hands would be the rash effort of attempting a survey of all the scientific results of the nineteenth century. It will be enough if for a little while I dwell on some few of the salient features distinguishing the way in which we nowadays look upon, and during the coming week shall speak of, the works of Nature around us—though those works themselves, save for the slight shifting involved in a secular change, remain exactly the same—from the way in which they were looked upon and might have been spoken of at a gathering of philosophers at Dover in 1799. And I ask your leave to do so.

THE KNOWLEDGE OF THE ELEMENTS.

In the philosophy of the ancients, earth, fire, air, and water were called "the elements." It was thought, and rightly thought, that a knowledge of them and of their attributes was a necessary basis of a knowledge of the ways of nature. Translated into modern language, a knowledge of these "elements" of old means a knowledge of the composition of the atmosphere, of water, and of all the other things which we call matter, as well as a knowledge of the general properties of gases, liquids, and solids, and of the nature and effects of combustion. Of all these things our knowledge to-day is large and exact, and though ever enlarging, in some respects complete. When did that knowledge begin to become exact?

To-day the children in our schools know that the air which wraps around the globe is not a single thing, but is made up of two things—oxygen and nitrogen*—mingled together. They know, again, that water is not a single thing, but the product of two things—oxygen and hydrogen—joined together. They know that when the air makes the fire burn and gives the animal life, it is the oxygen in it which does the work. They know that all round them things are undergoing that union with oxygen which we call oxidation, and that oxidation is the ordinary source of heat and light. Let me ask you to picture to yourselves what confusion there would be to-morrow, not only in the discussions at the sectional meetings of our Association, but in the world at large, if it should happen that in the coming night some destroying touch should wither up certain tender structures in all our brains and wipe out from our memories all traces of the ideas which cluster in our minds around the verbal tokens, oxygen and oxidation! How could any of us, not the so-called man of science alone, but even the man of business and the man of pleasure, go about his ways lacking those ideas? Yet those ideas were, in 1799, lacking to all but a few.

Although in the third quarter of the seventeenth century the light of truth about oxidation and combustion had flashed out in the writings of John Mayow, it came as a flash only, and died away as soon as it had come. For the rest of that century and for the greater part of the next philosophers stumbled about in darkness, misled for the most of the time by the phantom conception which they called phlogiston. It was not until the end of the third quarter of the eighteenth century that the new light, which has burned steadily ever since, lit up the minds of the men of science. The light came at nearly the same time from England and from France. Rounding off the sharp corners of controversy, and joining, as we may fitly do to-day, the two countries as twin bearers of a common crown, we may say that we owe the truth to Cavendish, to Lavoisier, and Priestley. If it was Priestley who was the first to demonstrate the existence of what we now call oxygen, it is to Lavoisier we owe the true conception of the nature of oxidation and the clear exposition of the full meaning of Priestley's discovery, while the knowledge of the composition of water, the necessary complement of the knowledge of oxygen, came to us through Cavendish, and we may, perhaps, add, through Watt.

The date of Priestley's discovery of oxygen is 1774, Lavoisier's classic memoir "on the nature of the principle which enters into combination with metals during calcination" appeared in 1775, and Cavendish's paper on the composition of water did not see the light until 1784.

During the last quarter of the eighteenth century this new idea of oxygen and oxidation was struggling into existence. How new was the idea is illustrated by the fact that Lavoisier himself at first spoke of that which he was afterward, namely in 1778, led to call oxygen, the name by which it has since been known, as "the principle which enters into combination." What difficulties its acceptance met with is illustrated by the fact that Priestley himself refused to the end of his life to grasp the true bearings of the discovery which he had made. In the year 1799 the knowledge of oxygen, of the nature of water and of air, and indeed the true conception of chemical composition and chemical change, was hardly more than beginning to be, and the century had to pass wholly away before the next great chemical idea, which we know by the name of the Atomic Theory of John Dalton, was made known. We have only to read the scientific literature of the time to recognize that a truth which is now not only woven as a master-thread into all our scientific conceptions, but even enters largely into the everyday talk and thoughts of educated people, was a hundred years ago struggling into existence among the philosophers themselves. It was all but absolutely unknown to the large world outside those select few.

THE WORD "ELECTRICITY."

If there be one word of science which is writ large on the life of the present time, it is the word "electricity"; it is, I take it, writ larger than any other word. The knowledge which it denotes has carried its practical results far and wide into our daily life, while the theoretical conceptions which it signifies pierce deep into the nature of things. We are to-day proud, and justly proud, both of the material triumphs and of the intellectual gains which it has brought us, and we are full of even larger hopes of it in the future.

At what time did this bright child of the nineteenth century have its birth?

He who listened to the small group of philosophers of Dover, who in 1799 might have discoursed of natural knowledge, would perhaps have heard much of electric machines, of electric sparks, of the electric fluid, and even of positive and negative electricity; for frictional electricity had long been known and even carefully studied. Probably one or more of the group, dwelling on the observations which Galvani, an Italian, had made known some twenty years before, developed views on the connection of electricity with the phenomena of living bodies. Possibly one of them was exciting the rest by telling how he had just heard that a professor at Pavia, one Volta, had discovered that electricity could be produced not only by rubbing together particular bodies, but by the simple contact of two metals, and had thereby explained Galvani's remarkable results. For, indeed, as we shall hear from Prof. Fleming, it was in that very year, 1799, that electricity as we now know it took its birth. It was then that Volta brought to light the apparently simple truths out of which so much has sprung. The world, it is true, had yet to wait for some twenty years before both the practical and the theoretic worth of Volta's discovery became truly pregnant, under the fertilizing influence of another discovery. The loadstone and magnetic virtues had, like the electrifying power of rubbed amber, long been an old story. But, save for the compass, not much had come from it. And even Volta's discovery might have long remained relatively barren had it been left to itself. When, however, in 1819, Oersted made known his remarkable observations on the relations of electricity to magnetism, he made the contact needed for the flow of a new current of ideas. And it is perhaps not too much to say that those ideas, developing during the years of the rest of the century with an ever-accelerating swiftness, have wholly changed man's material relations to the circumstances of life, and at the same time carried him far in his knowledge of the nature of things.

THE EVOLUTION OF GEOLOGY.

Of all the various branches of science, none perhaps is to-day, none for these many years past has been, so well known to, even if not understood by, most people

* Presidential Address to the British Association for the Advancement of Science, delivered at Dover, on Wednesday, September 13, 1899.

* Some may already know that there is at least a third thing—argon.

as that of geology. Its practical lessons have brought wealth to many; its fairy tales have brought delight to more; and round it hovers the charm of danger, for the conclusions to which it leads touch on the nature of man's beginning.

In 1799 the science of geology, as we now know it, was struggling into birth. There had been from of old cosmogonies, theories as to how the world had taken shape out of primæval chaos. In that fresh spirit which marked the zealous search after natural knowledge pursued in the middle and latter part of the seventeenth century, the brilliant Stenson, in Italy, and Hooke, in our own country, had laid hold of some of the problems presented by fossil remains, and Woodward, with others, had labored in the same field. In the eighteenth century, especially in its latter half, men's minds were busy about the physical agencies determining or modifying the features of the earth's crust; water and fire, subsidence from a primæval ocean, and transformation by outbursts of the central heat, Neptune and Pluto, were being appealed to, by Werner on the one hand, and by Desmarest on the other, in explanation of the earth's phenomena. The way was being prepared, theories and views were abundant, and many sound observations had been made; and yet the science of geology, properly so called, the exact and proved knowledge of the successive phases of the world's life, may be said to date from the closing years of the eighteenth century.

In 1788, James Hutton put forward in a brief memoir his "Theory of the Earth," which in 1795, two years before his death, he expanded into a book; but his ideas failed to lay hold of men's minds until the century had passed away, when, in 1802, they found an able expositor in John Playfair. The very same year that Hutton published his theory, Cuvier came to Paris, and almost forthwith began, with Brongniart, his immortal researches into the fossils of Paris and its neighborhood. And, four years later, in the year 1799 itself, William Smith's tabular list of strata and fossils saw the light. It is, I believe, not too much to say that out of these geology, as we now know it, sprang. It was thus in the closing years of the eighteenth century that was begun the work which the nineteenth century has carried forward to such great results. But at that time only the select few had grasped the truth, and even they only the beginning of it. Outside a narrow circle the thoughts, even of the educated, about the history of the globe were bounded by the story of the Deluge—though the story was often told in a strange fashion—or were guided by fantastic views of the plastic forces of a sportive Nature.

(To be continued.)

AFTER GENERATION OF ACETYLENE.

The most serious problem in the generation of acetylene on a small scale is the after-formation of gas in the generator. This is discussed by P. Wolff in The Metallarbeiter, and reproduced in The Chemical News. According to Wolff this after-generation is due to three causes: the action of the residual water contained in the pores of the carbid, the condensation of water on the surface of the carbid, and the absorption of aqueous vapor. In an experiment where the carbid reservoir was over petroleum, the after-generation was 6 liters in 24 hours, 16 liters in three days, and remained constant at this figure. Over water 25 liters were given off in one day, and 30 liters in three days. The generation of gas continued at five or six liters a day until the carbid in the generator was completely decomposed. This shows the danger in small generators where there can be no large reservoir. In large apparatus a gas reservoir can be attached which will have capacity to hold this generated gas and that without compression, which would render it dangerous. The best device is spoken of as being that of Münsterberg, which not only has a relatively large reservoir, but a device for closing the carbid chamber by an air-tight valve which completely shuts off the chamber when the apparatus is not in use. No mention is made of the device which has been used in this country, where the carbid is dropped in small lumps into water. As each piece exhausted a new portion is fed automatically.

Previous mention has been made in these columns concerning the work now being carried out on the cantilever bridge across the Niagara River, just below Niagara Falls, by which a third truss will be added to strengthen the existing structure, made necessary by the increased weight of rolling stock since the bridge was designed in 1890. With the view of ascertaining the profile of the river bottom under this bridge, the Michigan Central Railroad recently took soundings at this point. The bridge is situated just over the head of the whirlpool rapids, where the current is very swift, and unusual methods had to be resorted to in getting the depth. The sinkers on the sounding lines were egg-shaped masses of cast iron, one weighing 600 pounds and the other 150 pounds, the sounding line being a steel wire about ⅛ inch in diameter. In order to keep the sinkers from twisting, a long fin was attached to the rear of each. The depth at midstream was ascertained to be 78 feet, and the depth at 100 feet from shore 43 feet. In the course of subsequent soundings the weights were lost. By means of these sounding the engineers were able to make accurate maps of the river at the point of crossing, the importance of which may be readily surmised when it is known that the piers supporting the cantilever bridge are located close to the water's edge on either side of the stream.—Railway Review.

The following table shows the tonnage of seagoing vessels now in course of construction throughout the world:

Country.	Steamers.	Sailing vessels.
Great Britain	1,386,300	1,700
Germany	198,780	1,520
Italy	68,100	4,400
United States	59,700	4,900
France	43,900	5,900
Holland	27,200	8,700
Denmark	17,500	1,300

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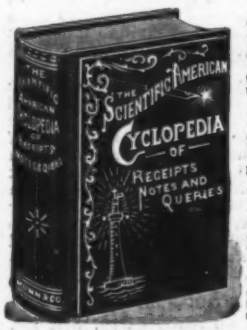

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